ENVIRONMENTAL OVERVIEW ASSESSMENT OF FOUR POTENTIAL RESERVOIR SITES IN THE LITTLE BOW RIVER BASIN

Prepared For

Alberta Environment
Planning Division

Prepared By

Beak Associates Consulting Ltd.
Suite 417, 10512 - 169 Street
Edmonton, Alberta
T5P 3X6

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EXECUTIVE SUMMARY

An environmental overview assessment was conducted for four potential water storage reservoir sites in the Little Bow River basin, southeast of Calgary, Alberta. The four sites are listed as follows:

- **Site LB1** - Little Bow River near Frank Lake;
- **Site 2** - Squaw Coulee upstream of the confluence with Mosquito Creek;
- **Site 7B1** - Little Bow River below the confluence with Mosquito Creek; and
- **Site 7A** - Little Bow River downstream of the Fireguard Road.

The study involved an assessment of five categories of environmental resources: soils and surficial geology, land use, water quality, fisheries, and wildlife. Pertinent environmental issues related to each site were identified based on available data and a two-day field reconnaissance of the sites. The environmental resources of each site were compared and ranked in terms of their relative vulnerability due to flooding.

Soils and Surficial Geology

An assessment of the soils and surficial geology revealed that the flooding of Site 2 would cause the smallest divestment in the agricultural land base due to the small amount of arable land at that site (approximately 50 ha). Conversely, the flooding of Site 7A and, to a slightly lesser degree, Site 7B1, would cause the greatest loss of arable land (approximately 500 ha). Site LB1 would lose an intermediate amount of arable land (approximately 250 ha) compared to the other three sites; however, it would lose the greatest amount of arable land relative to its size. Soil erosion hazard and surface stability is considered to be fairly similar at all four sites. The suitability of the topsoil and subsoil for reclamation purposes is also similar at all four sites.

Land Use

The primary land use at the four potential reservoir sites is agriculture, composed of dryland farming, irrigation and ranching. Other land uses include roads, sand and gravel extraction areas, historic sites, transmission lines and farmsteads. Despite the variability of land uses at each site, it appears that the areal extent of each reservoir site is the primary factor in determining which site will be most heavily impacted by flooding. Since Site 7A would flood the greatest land area, this site would be most vulnerable to land use impacts. Slightly fewer impacts would be expected to occur at Site 7B1. Site 2 is rated as having the least impacts from a land use perspective because of its small size and relatively low value land uses. Site LB1 would have intermediate land use impacts, but would have the greatest impacts relative to its size.

Water Quality

The primary water source for any new reservoir will behigh quality Highwood River water, plus small inputs of lower quality Little Bow River flows. Alberta Environment has predicted that all four reservoirs will be oligotrophic to mesotrophic, with slightly higher productivity in Site 7B1 and Site 7A. Neither winterkill or summerkill of fish is expected to be of concern except during periods of extreme drawdown. An initial high rate of productivity is anticipated after flooding. The release of mercury into the reservoir is a concern and should be monitored. Release below the reservoir is predicted to improve downstream water quality.

Fisheries Resource

At present, fish habitat within the study area is marginal. In general, factors limiting fish distribution in the Little Bow River are lack of suitable substrate, lack of instream and riparian cover, and sub-optimal winter dissolved oxygen concentrations. Of the four sites, development of a reservoir at Site 2 would result in the smallest lost of stream habitat, plus the greatest potential for positive benefits from downstream flow augmentation. Productivity would likely be greater in either 7B1 or 7A due to their larger size, and both are probably less

vulnerable to winter kill than the two smaller reservoirs. All four reservoirs appear likely to experience significant drawdown causing unknown, but probably serious reductions in productivity. Negative impacts from reservoir development will likely include loss of rainbow trout from the Bow River system, and high mercury concentration in the tissue of resident sport fish.

Wildlife Resource

Due to the extensive agricultural activity occurring at the four reservoir sites and surrounding area, none are considered to have a high capability for supporting wildlife. The greatest single impact of flooding on wildlife would be the direct loss of habitat. A significant portion of the upland wildlife habitat on the slopes would be flooded and the remaining portion that is not flooded could be susceptible to erosion due to a lack of stabilizing vegetation below. Wherever there is a small stand of trees, shrubs, or shoreline vegetation that has not been clearerd or disturbed by agricultural development, there is use of that area by wildlife for food and cover. Thus, Site 7A, which has the largest area of native land, has the greatest value from a wildlife standpoint and would be rated highest in terms of flood related impacts. Site 7B1 has a similar, but somewhat smaller, areal extent of native land and therefore would receive a slightly smaller flood impact rating. Site LB1 would be ranked as intermediate in terms of wildlife impacts, but would have the greatest impacts relative to its size. Site 2, which has only a very limited amount of native land, will likely be the least impacted by the construction of a reservoir.

Conclusions

To determine the relative difference in <u>overall</u> environmental impacts at each site, a subjective, qualitative ranking system was derived for the critical environmental issues identified in this study. The results of this summary evaluation revealed that the different sites would suffer environmental impacts in the following order:

- **Site 2 -** least environmental impacts as compared with other sites (most favorable reservoir site;

- **Site LB1 -** intermediate environmental impacts as compared with other sites (considerably less favorable than Site 2, but better than Sites 7B1 and 7A);

- **Sites 7B1 and 7A -** greatest environmental impacts as compared with other sites (substantially less favorable than Sites 2 and LB1).

In arriving at the above conclusion, one factor in each category of environmental resources became dominant in the decision-making. These factors are discussed below, as follows:

Category of Environmental Resource	Determining Factor
Surficial Geology and Soils	Areal extent of arable land
Land Use	Areal extent of high value land
Water Quality	Reservoir trophic status
Fisheries Resource	Quality of spawning and rearing habitat
Wildlife Resource	Areal extent of native land

This report was prepared using a small, non-specific data base. Since it was the purpose of the study only to identify environmental impacts at each reservoir site, no attempt was made to weigh these impacts against benefits to occur outside the study area. Further studies will be required to verify conclusions and to fill in data gaps identified in this report. Once site-specific data are available, specific mitigation measures can be developed to diminish or eliminate negative impacts.

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Mr. Ron Middleton	-	Coordinated all Project Phases and Reviewed Draft Report
Ms. Jan Crosby	-	Reviewed Water Quality Section
Mr. Leigh Noton	-	Reviewed Wildlife Section
Mr. John Englert	-	Reviewed Fisheries Section
Mr. Bryan Kemper	-	General Advice on Draft Report
Ms. Brenda Brassard	-	Provided Baseline Water Quality Information
Mr. Lorand Szojka	-	Provided General Project Input
Mr. Manuel Dasilva	-	Drafted Map Legends and Title Blocks

Numerous other government officials from other provincial and federal departments provided information about specific environmental issues. Certain landowners also provided valuable environmental information relative to their locations. Both the government officials and landowners are listed in Section 8.2 of the report.

The BEAK study team was comprised of the following people:

Patricia Cary	-	Environmental Planner
David Van Seters	-	Environmental Biologist
Brian Bietz	-	Aquatic Scientist
John Martin	-	Resource Ecologist
Robyn Usher	-	Wildlife Biologist
Bob Shelast	-	Fisheries Biologist

Sub-consultants to the project included:

Len Knapik	-	Soil Scientist - Pedacan Land Evaluation Ltd.
Rick Dressler	-	Draftsman - R.S.D. Canadian Geographics Ltd.

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1.0 INTRODUCTION

1.1 Background and Project Scope

Alberta Environment has considered constructing a water storage reservoir in the Little Bow River basin for several years. To date, studies have been conducted to examine the hydrological regime, inventory water use and supply, and investigate preliminary storage alternatives. Additional engineering and environmental studies have also been carried out (see Appendix A: Existing Data Base).

Beak Associates Consulting Ltd. was retained in October 1985 by Alberta Environment Planning Division to provide an environmental overview of three potential reservoir sites within the basin. In December 1985, the Planning Division requested a similar examination of a fourth site.

This study represents Phase 2 of a three phase environmental assessment process to select a water storage reservoir site in the Little Bow River Basin. In the initial assessment phase, which was conducted by our firm in 1983, regional overview information was compiled for the entire Little Bow River Basin. This general information was useful in developing a broad perspective of the environmental resources of the basin. In the second phase, for which this report has been prepared, an environmental overview was conducted for specific sites within the river basin. This information is qualitative in nature and enables a comparison of environmental resources among the four sites. If the project proceeds further, a final assessment phase will be employed at the selected site to quantify environmental impacts and to identify mitigative measures to reduce those impacts.

It is the general purpose of this study to provide a broad overview of the respective environmental resources of the four reservoir sites to allow comparisons among the sites in terms of the relative environmental sensitivity and impacts. The information contained in this report will be used in conjunction with engineering feasibility studies and a local concerns assessment to select a final reservoir site.

The objectives of the environmental overview were to:

- provide a description of the environmental resources of the water storage sites, based primarily on existing information. Components addressed included: fisheries, wildlife, land use, soils and surficial geology, and water quality;

- identify the pertinent environmental issues related to each site on the basis of existing data and a two-day field reconnaisance of the sites;

- identify significant gaps in the environmental data base that should be filled in order to complete the environmental assessment;

- compare each of the water storage sites from an environmental perspective and rank them according to their relative impacts; and

- identify environmental costs, benefits, and opportunities associated with each site.

1.2 Regional and Site Information

The Little Bow River originates south of Calgary in the hills west and northwest of Nanton. The river flows southeast and joins the Oldman River downstream of Lethbridge.

Water is diverted from the Highwood River into the Little Bow River at two locations. One diversion point (1.7 cms or 60 cfs capacity) is located five miles upstream of the Town of High River and directs water through Squaw Coulee and Mosquito Creek and eventually into the Little Bow River. The other point of diversion (2.8 cms or 100 cfs capacity) is located within the High River Town boundaries and channels water through a diversion canal directly into the Little Bow River. During the growing season, a significant portion of the water in the Highwood River is drawn off for irrigation purposes in the Little Bow River Basin. In dry years, existing water supplies are insufficient to meet the demands of the irrigation users without causing a negative effect on the Highwood River.

All of the potential water storage sites are located in the upper reaches of the basin.

The locations of the four sites are shown in Figure 1.1 and listed below:

- Site LB1 - Little Bow River near Frank Lake
- Site 2 - Squaw Coulee upstream of the confluence with Mosquito Creek
- Site 7B1 - Little Bow River below the confluence with Mosquito Creek
- Site 7A - Little Bow River downstream of the Fireguard Road

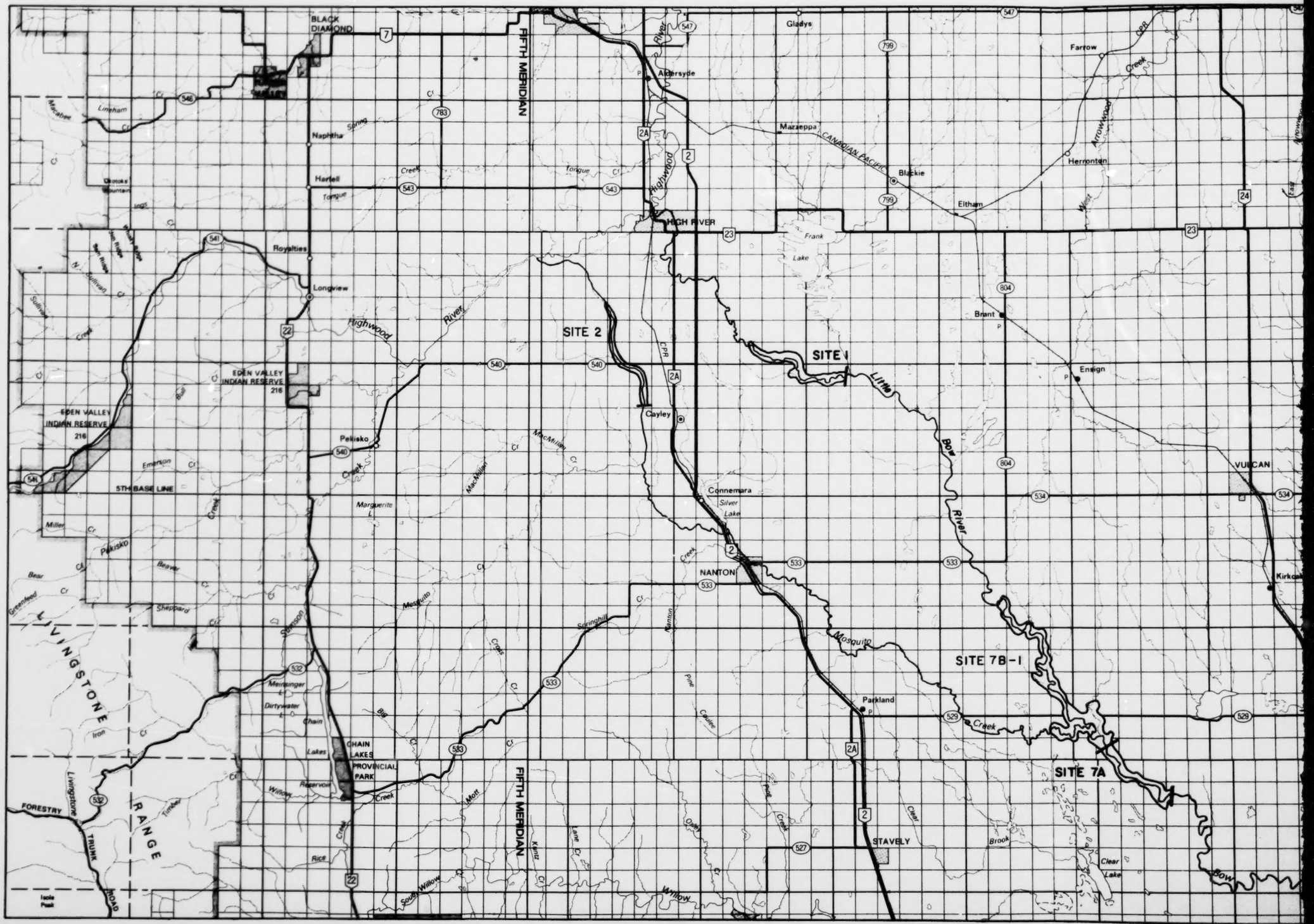
Some physical data describing the potential reservoirs are provided in Table 1.1. It is relevant to note that both Sites 7B1 and 7A flood about three times the area of the other two sites and have a capacity about four times greater.

Table 1.1 Reservoir Descriptions

	Site LB1	Site 2	Site 7B1	Site 7A
Dam Location	NE32-17-27-W4	SE26-17-29-W4	NW5-15-25-W4	W27-14-25-W4
Height of Dam	17 m	19.5 m	25 m	27 m
Full Supply Level (FSL)	1002.8 m	1066.8 m	964.7 m	962 m
Storage Volume at FSL	21.28 x $10^6 m^3$	17.76 x $10^6 m^3$	86.30 x $10^6 m^3$	86.30 x $10^6 m^3$
Flooded Area at FSL[a]	328 ha	243 ha	approx 1020 ha	approx 1060 hr

[a] Flooded area at FSL for Sites 7B1 and 7A were calculated using a grid overlay technique on 1:20,000 scale photo mosaics since engineering data are not currently available.

Source: Adapted from W-E-R Engineering Ltd., 1985.


BLACK DIAMOND
FIFTH MERIDIAN
Gladys
Aldersyde
Farrow
Mazeppa
CANADIAN PACIFIC
Blackie
Eltham
Hereonten
HIGH RIVER
Frank Lake
Royalties
Longview
Naphtha
Hartell
Limeham
Highwood River
Arrowwood Creek
CPR
West Arrowwood Creek
East Arrowwood Creek
SITE 2
SITE 1
Brant
Ensign
Cayley
LITHIA
Bow River
VULCAN
Connemara
Silver Lake
NANTON
Mosquito Creek
SITE 7B-1
Parkland
SITE 7A
STAVELY
Clear Lake
Bow
EDEN VALLEY INDIAN RESERVE 216
Pekisko
Marguerite L.
MacMillan Creek
5TH BASE LINE
Miller Cr
Beaver Cr
Sheppard Cr
Bear Cr
Greenhead Cr
Stanson Creek
Meiranger L.
Dirtywater L.
Chain Lakes
CHAIN LAKES PROVINCIAL PARK
Reservoir Creek
Willow Creek
Rice Creek
Big Cr
Springhill Cr
Nanton Cr
Pine Coulee
Crags Cr
Oakley Creek
Pine Creek
Lane Cr
Kurtz Cr
Marlow Cr
South Willow Cr
Iron Cr
Livingstone Range
FORESTRY TRUCK ROAD
Indian Peak
LIVINGSTONE
Sullivan Creek
N. Sullivan Cr
Sullivan River
Ball Cr
Emerson Cr
Timber Cr
Macabee Cr
Stokes Mountain
Ings Cr
Tongue Cr
Spring Creek
Tongue Creek
Highwood River
Frank Lake
Silver Lake
Clear Lake
Indian Peak
Pekisko
Nanton
Parkland
Brant
Ensign
Vulcan
Kirkcaldy
Stavely
Cayley
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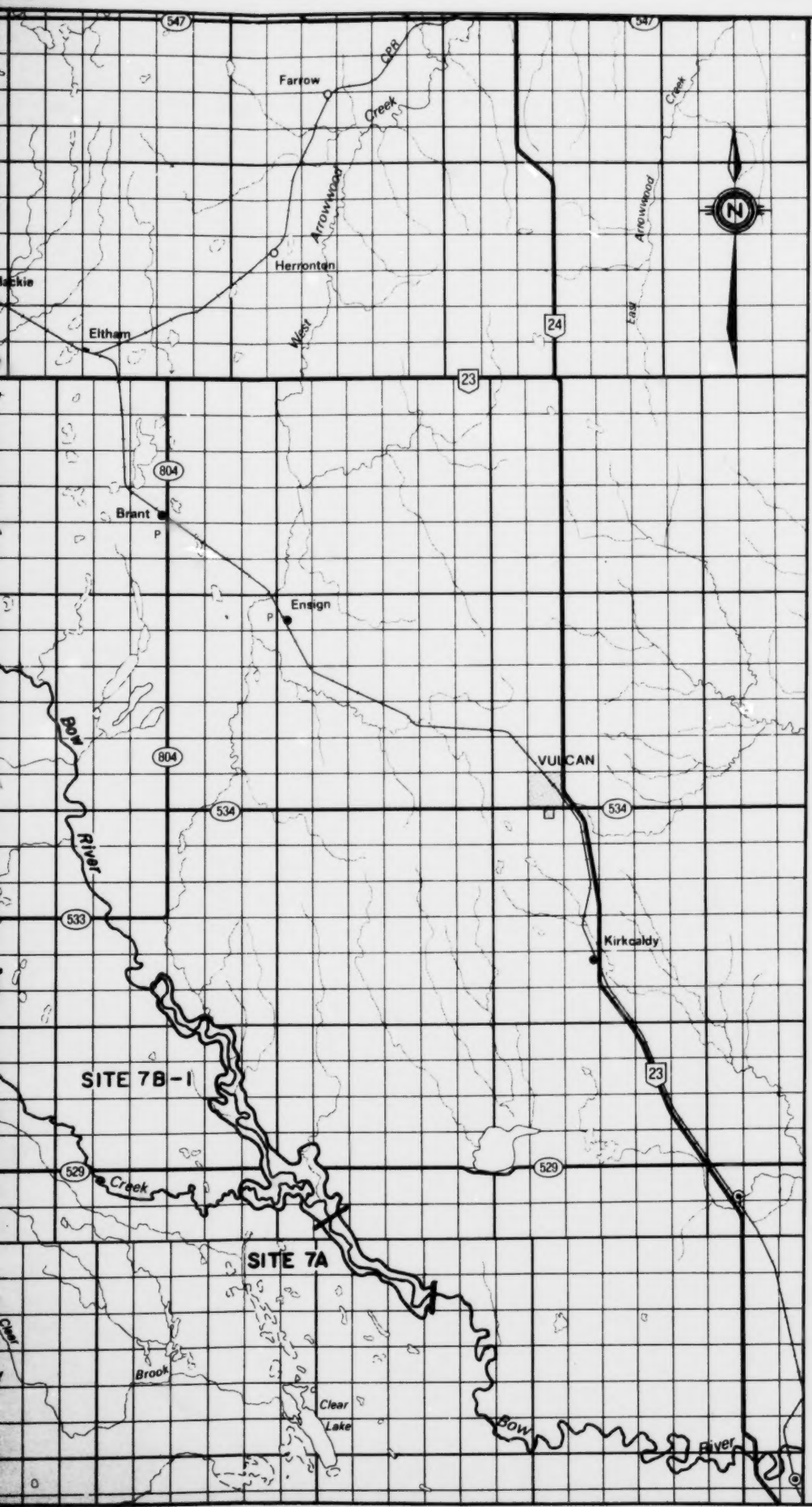


LITTLE BOW RIVER BASIN

LOCATION PLAN

SCALE 1:250 000

Fig. 1.1

Operating regimes for the reservoir locations have been determined conceptually. The reservoir will be filled during spring freshet with water from the Highwood River. Diversions from the Highwood will be continued as long as flows in the Highwood permit, in order to replace reservoir outflows. Drawdown will occur during summer months and no attempt will be made to fill the reservoir in the fall. Existing diversions will be maintained through the winter months, Highwood flows permitting. Maximum diversion flow into the Little Bow River would be 8.6 m^3/s (300 cfs), comprised of 6.9 m^3/s (240 cfs) in the Little Bow Canal and 1.7 m^3/s (60 cfs) in the Highwood Diversion Canal which drains into Mosquito Creek. As Highwood River flows decline below 12.9 m^3/s (450 cfs), diversion into the Little Bow River will be curtailed in order that Highwood River flows below the diversion point do not drop below 4.3 m^3/s (150 cfs). Flows below the reservoir would be maintained at a minimum flow of 0.3 - 0.6 m^3/s (10-20 cfs) during the winter months for domestic use by Carmangay and/or Vulcan.

Table 1.2, based on drawdown frequency data for the Crawling Valley Reservoir (supplied by Alberta Environment), gives the estimated probability that drawdowns of specific magnitude will occur duing a given year at each of the reservoir sites. The three scenarios, for years 1, 10, and 20, reflect the gradual expansion of existing irrigation demands that is expected to occur once the reservoir has been constructed. Expansion to maximum irrigation is expected to occur over a 10 year period for the smaller reservoirs at sites 1 and 2 and over a 20 year period for sites 7A and 7B1.

Table 1.2 **Estimated frequency of drawdowns of specific magnitudes for the four Little Bow reservoir sites.**

			drawdown greater than (% of years)					
		Maximum Depth	5'	10'	20'	30'	40'	50'
Site LB1								
Year	1	47'	53	36	18	9	5	0
	10		73	57	36	24	20	0
	20		73	57	36	24	20	0
Site 2								
Year	1	55'	56	39	22	12	6	0
	10		75	61	41	28	21	3
	20		75	61	41	28	21	16
Site 7B1								
Year	1	63.7'	36	22	9	2	0	0
	10		59	42	26	16	9	5
	20		77	60	46	32	24	20
Site 7A								
Year	1	80.1'	41	27	13	5	0	0
	10		66	48	31	21	14	10
	20		78	69	52	40	31	24

Source: Adapted from drawdown frequency data for the Crawling Valley Reservoir (supplied by Alberta Environment Planning Division).

2.0 SOILS AND SURFICIAL GEOLOGY

The following inventory of the surficial geology and soils was based largely on air photo interpretation. An exploratory field reconnaissance was conducted to ground truth the land units. The ratings of soil capability for agriculture, the presence or absence of erosion or mass-movement, and soil quality for reclamation were based on interpretation of the Surficial Geology-Soils Maps. While the data are presented at a detailed scale (1:20,000) they can only be considered overview information since intensive field inspection and soil sampling were not conducted.

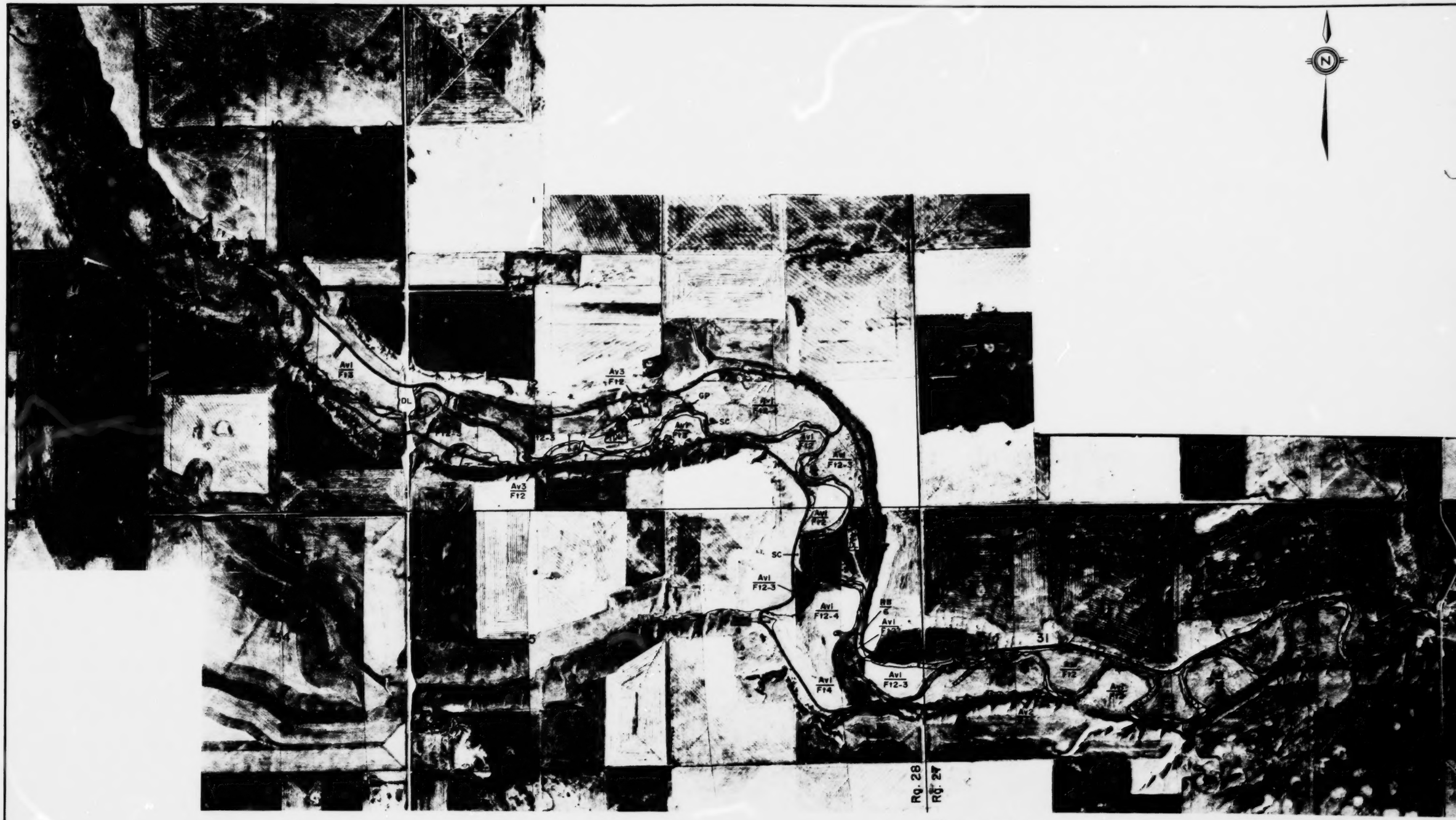
2.1 Soils and Surficial Geology

2.1.1 Site LB1

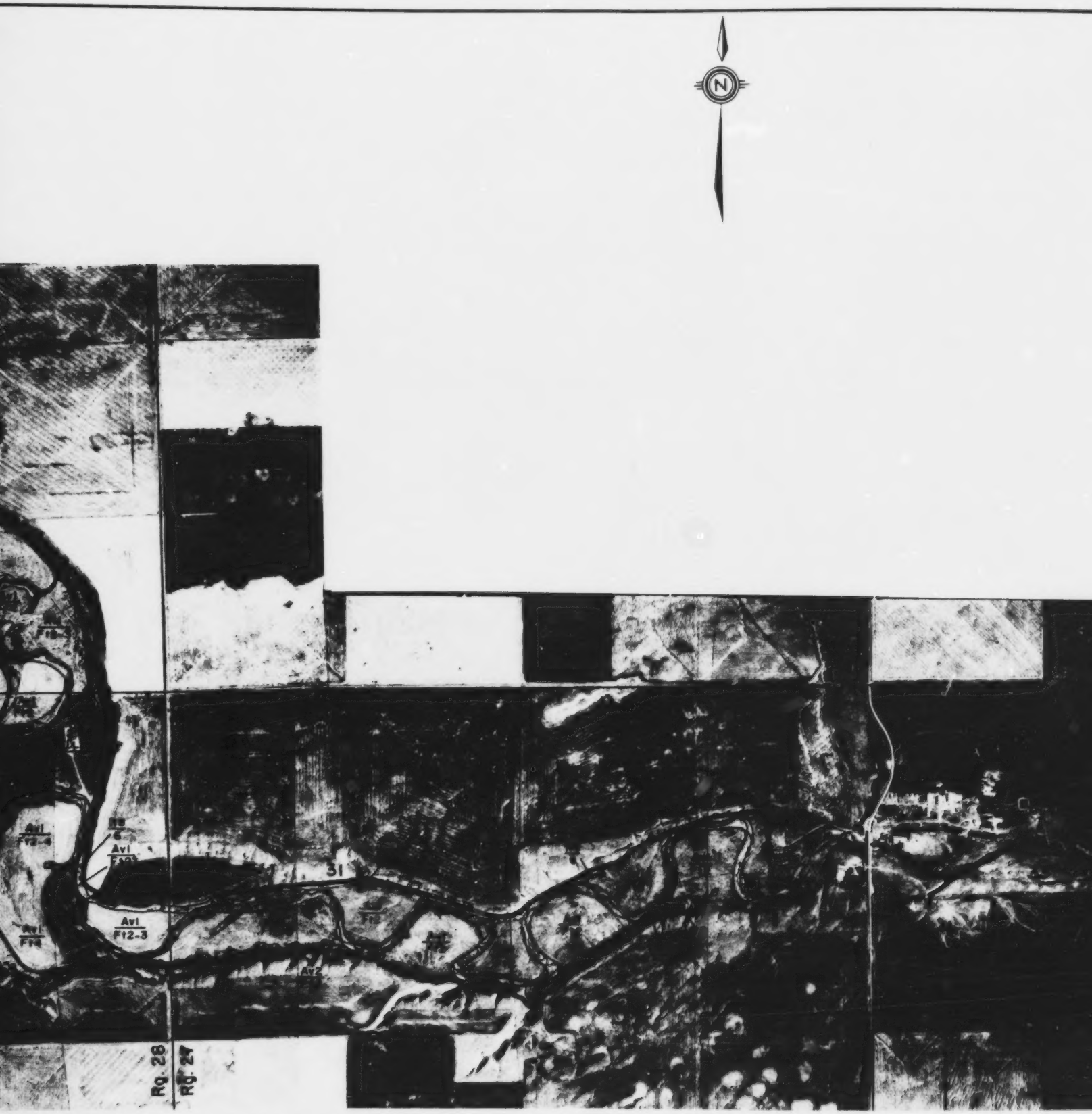
The Little Bow River at Site LB1 is a meandering stream in a deeply incised post-glacial outwash channel approximately 400 to 700 m across the top and 250 to 500 m across the bottom. The downcutting took place in the later part of the Pleistocene and in the early Holocene geological periods with fluvial deposition occurring in the Holocene period. The geology of the Little Bow River Basin was described in IEC Beak (1983). The surficial geology and soils of Site LB1 are mapped on the enclosed Geology-Soils Map (Figure 2.1) and summarized in Table 2.1.

The valley bottom contains depositional fluvial terraces with nearly level to undulating landscapes. Small escarpments with slopes of 6 to 15 percent separate different terrace levels. Soils are predominantly Cumulic Humic Regosols and Orthic Humic Regosols with loam to sandy loam textures and occasional deposits of coarse sand and gravel (Av1/Ft units on map).

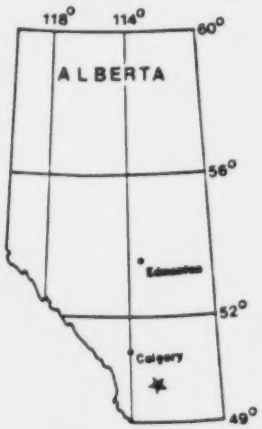
A few small fluvial fans and aprons abut the river banks on gentle to moderate slopes (6 to 15 percent). These landforms have Orthic and Rego Black Chernozemic soils with loamy to sandy loam textures (Av2/Ff or Fa units on map).



FSL at 3290 feet



FSL at 3290 feet



INDEX MAP

LEGEND

Notations: Av1 ← Soil Symbol
Ft2 ← Topography Class
A ← Landform

Soil Symbol	Soil Classification	Parent Material	Dominant Texture	Drainage
Av1	Cumulic Humic and Orthic Humic Regosols	fluvial	loam to fine sandy loam	well
Av2	Orthic and Rego Black Chernozems	fluvial	loam	well
Av3	Orthic and Orthic Humic Gleysols, often saline	fluvial	loam to fine sandy loam	poorly

Miscellaneous Units:

RB - river banks: these steeply sloping units have variable soils and undifferentiated surficial material. Bedrock may occur at the surface especially in slumped areas.

SC - stream channels: this unit includes the stream and its adjacent banks.

GP - gravel pits

DL - disturbed lands: miscellaneous disturbed lands; i.e., roads, farmyards.

- small escarpments: this symbol was used to designate small escarpments on terraced landscapes. Slopes are generally Class 4 and do not severely limit cultivation.

- slumped: river banks that have slumped.

Topography Classes

Topo Class	Slope %	Description
2	0-2	very gently sloping
3	2-5	gently sloping
4	6-9	moderately sloping
5	10-15	strongly sloping
6	16-30	steeply sloping
7	31-45	very steeply sloping

Landforms

Genetic Material	Surface Expression
F - fluvial	a - apron
	f - fan
	t - terraced

1:20000

0 0.5 1 km

0 0.5 1 mile

ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 2.1

SURFICIAL GEOLOGY AND SOILS

LITTLE BOW RIVER BASIN - SITE LB1

POTENTIAL RESERVOIR VOLUME: 21 000 000 m³

Prepared by PEDOCAN LAND EVALUATION LTD. for
BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

Table 2.1 Summary of Soil Ratings for Agriculture, Erosion Occurrence, and Soil Quality

Map Unit		Soil Capability for Agriculture[1]	Current Erosion or Sedimentation[2]		Soil Capability for Reclamation[3]	
Soil Unit	Topography[1]		Slumps	Intermittent Runoff Channels	Topsoil	Subsoil
SITE LB1						
Av1	2,2-3,3,2-4	3T	-	-	GF	GF
Av2	4	3T	-	-	GF	GF
	5	4T	-	-	GF	GF
Av3	2	5N	-	-	P	P
RB	6,7	6T	+	+	GF	GF
	4-5	4T	-	-	GF	GF
SITE 2						
Av1	3,3-4,4 3-4,4	3T	-	-	GF	GF
Av2	2	6S	-	-	P	P
RB	5-6	6T	+	+	GF	GF
SITE 7B1						
Av1	2,2-3,3 3-4	3T	-	-	GF	GF
Av2	3-4,4	3T	-	-	GF	GF
Av3	2-3,3	4W	-	-	GF	GF
RB	4-5,5	5T	+	+	GF	GF
	5-6,6	6T				
	4-5	4T	-	-	GF	GF
SITE 7A						
Av1	2,2-3,3 3-4	3T	-	-	GF	GF
	4	4T	-	-	GF	GF
Av2	3-4,4	3T	-	-	GF	GF
Av3	2-3,3	4W	-	-	GF	GF
Av4	2	6S	-	-	P	P
RB	4-5,5	5T	+	+	GF	GF
	5-6,6	6T	+	+	GF	GF
	4-5	4T	-	-	GF	GF

1 based on Canada Land Inventory (CLI) system guidelines (Appendix B)
2 + = present; - = absent
3 GF = good to fair; P = poor

Some small depressional, salinized areas on the fluvial terraces occur in Section 2-28-18-W4. These areas are poorly drained with Orthic and Orthic Humic Gleysolic soils that are salinized (Av3/Ft units on map). The river banks are steeply sloping (16 to 30 percent slopes) with occasional inactive gullies that extend well back from the river valley (RB units on map). Periods of runoff have contributed to the development of fans below them. Slumping has occurred in isolated spots along the river banks. The surficial geological materials are variable, ranging from glaciofluvial to till and occasional thin colluvial veneers. The till is derived predominantly from local bedrock and the glaciofluvial materials are predominantly quartzites. Soft bedrock often occurs near the surface. Soils are an undifferentiated complex of primarily Orthic Regosols and Orthic Humic Regosols.

2.1.2 Site 2

Squaw Coulee at Site 2 is a deeply incised V-shaped post-glacial outwash channel approximately 280 to 650 m across the top and 80 to 200 m across the bottom. The soils and surficial geology of this site are mapped in Figure 2.2 and summarized in Table 2.1.

The stream channel is small and has been straightened by ditching in the northern part of the area. It is bordered by a fluvial floodplain with loam to sandy loam textured sediments. The soils on the floodplain (Av2/Fp units on map) are poorly drained saline Orthic Humic Gleysols with severe limitations for any agricultural use. Between the floodplains and the steep river banks are lacustrine aprons and inclined fluvial fans. Prominent fans occur beneath larger gullies that extend back from the coulee. The majority of the fans are complexed with the lacustrine deposits. Sediments range in texture from loam to clay and slopes are 2 to 9 percent. The soils are dominantly Orthic and Rego Blacks with some Cumulic Humic Regosols (Av/FLf units on map).

The river banks (RB units on map) are strongly to steeply sloping (9 to 30 percent) with numerous small gullies extending back from the river valley. Sedimentation still occurs below these gullies during major runoff periods. Soils are undifferentiated complexes of dominantly Regosolic soils. The parent materials include

colluvial, glaciofluvial and till veneers and blankets. Bedrock is near the surface and is exposed at many locations. The exposed bedrock is resistant sandstone of the Porcupine Hills Formation, described by Green (1972) as non-marine, pale gray, thick-bedded, cherty calcareous sandstone and pale gray calcareous mudstone.

N
Av2
Fl2
Av1
FLt 3-4

INDEX MAP

LEGEND

Notations: Av1 ← Soil Symbol
FL1 3-4 ← Topography Class
└ Landform

Soil Symbol	Soil Classification	Parent Material
Av1	Orthic and Rego Black; Cumulic Humic Regosol	fluvial & lacustrine
Av2	Orthic Humic Gleysols, often saline	fluvial

Miscellaneous Units:

RB - river banks: these steeply sloping surficial material. Bedrock often Sandstone outcrops are common.

SC - stream channel: this unit includes floodplains and steep short banks.

DC - ditched stream channel: stream chan

DL - disturbed lands: miscellaneous distur

Topography Classes

Topo Class	Slope %	Description
2	0-2	very gently sloping
3	2-5	gently sloping
4	6-9	moderately sloping
5	10-15	strongly sloping
6	16-30	steeply sloping

1:20000

0 0.5

0 0.5

ALBERTA ENVIRONMENT P

Figure 2.

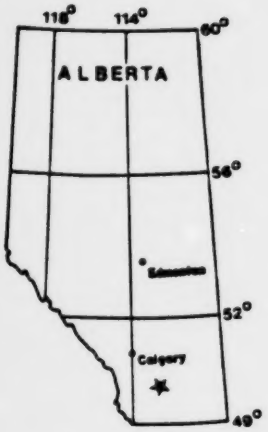
SURFICIAL GEOLOG

LITTLE BOW RIVER B

POTENTIAL RESERVOIR VOL

Prepared by PEDOCAN LAND
BEAK ASSOCIATES CO

SCALE 1:20000



INDEX MAP

LEGEND

Notations: Av1 ← Soil Symbol
FL[3-4 ← Topography Class
L ← Landform

Soil Symbol	Soil Classification	Parent Material	Dominant Texture	Drainage
Av1	Orthic and Rego Black; Cumulic Humic Regosol	fluvial & lacustrine	loam to clay	well moderately
Av2	Orthic Humic Gleysols, often saline	fluvial	loam	poorly

Miscellaneous Units:

RB - river banks: these steeply sloping units have variable soils and surficial material. Bedrock often occurs near or at the surface. Sandstone outcrops are common.

SC - stream channel: this unit includes the stream and its immediate floodplains and steep short banks.

DC - ditched stream channel: stream channel straightened by ditching.

DL - disturbed lands: miscellaneous disturbed lands; i.e. roads, farmyards.

Topography Classes

Topo Class	Slope %	Description
2	0-2	very gently sloping
3	2-5	gently sloping
4	6-9	moderately sloping
5	10-15	strongly sloping
6	16-30	steeply sloping

Landforms

Genetic Material	Surface Expression
F - fluvial	f - fan
FL - fluvial & lacustrine	p - floodplain
	t - terraced

1:20000

0 0.5 1 km

0 0.5 1 mile

ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 2.2

SURFICIAL GEOLOGY AND SOILS

LITTLE BOW RIVER BASIN - SITE 2

POTENTIAL RESERVOIR VOLUME : 18 000 000 m³

Prepared by PEDOCAN LAND EVALUATION LTD. for
BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

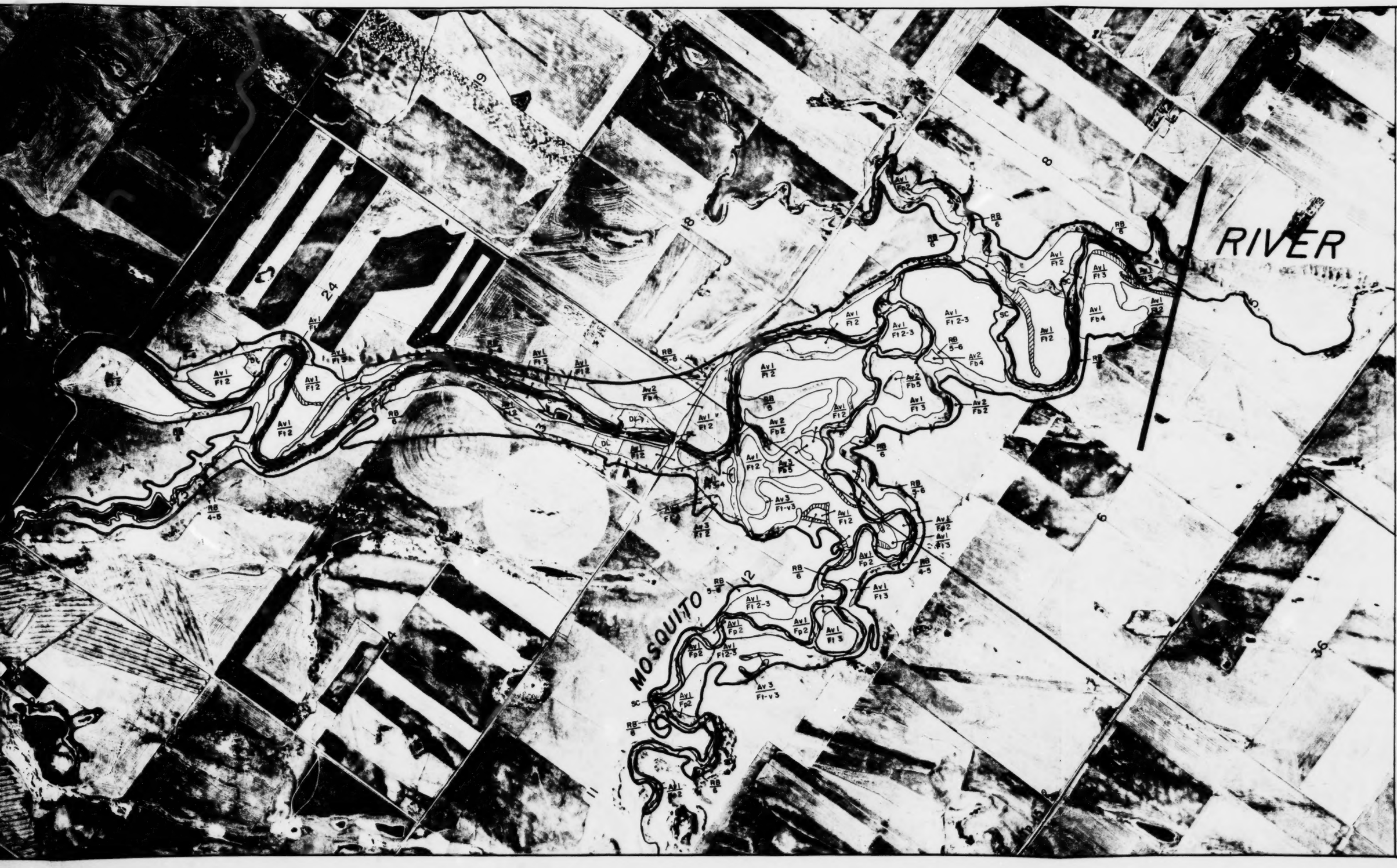
2.1.3 Site 7B1

Site 7B1 includes the valleys of the Little Bow River and Mosquito Creek. The Little Bow valley is as much as 1000 m wide across the top and up to 800 m across the bottom. The northern part of the area has a less distinct river bank that ascends to the level of the surrounding plain in a series of terraces and low banks. Where Mosquito Creek joins the Little Bow River, the valley is enlarged. Figure 2.3 illustrates the areal distribution of the surficial geology and soils at Site 7B1. A summary of soil ratings is provided in Table 2.1.

The present stream channel meanders through depositional fluvial terraces, isolating many of them. The terraces are nearly level to undulating with small escarpments (slopes 6 to 16 percent) separating various levels of terraces. These are especially common in the Mosquito Creek valley bottom. A small fluvial floodplain borders Mosquito Creek with a distinct second level of terraces above it. Cumulic Humic Regosolic and Orthic Regosolic soils are developed in these fine sandy loam to loam textured deposits (Av1/Ft units on map). The terraces are occasionally dissected by old stream channels, which carry only intermittent runoff. Soils in them are Orthic Humic Gleysols and Orthic Humic Regosols (Av3/Ft-V units on map). The northern part of the area contains some outwash terraces well above the other terraces. Landscapes are undulating to gently rolling (2 to 9 percent slopes). These areas contain Orthic and Rego Dark Brown Chernozemic soils with sandy loam to loam textures (Av2/F1 units on map).

The river banks (RB map units) are strongly to steeply sloping (10 to 60 percent). In many areas the river banks are discontinuous and separate the different terrace levels. Distinct gullies extend well back from the valley and serve as intermittent runoff channels. Isolated slumping occurs along the Mosquito Creek banks. The soils along this unit are an undifferentiated complex, but are primarily Orthic and Orthic Humic Regosols. The surficial geological material is variable, ranging from till to glaciofluvial with some colluvial veneers. Horseshoe Canyon Formation bedrock occurs near the surface and often outcrops at the surface.

LIT


RIVER
MOSQUITO
INDEX M
118°
114°
ALBERT
Av1 Fl2
Av1 Fl2-3
Av1 Fl3
Av1 Fb4
Av2 Fb4
Av2 Fb5
Av2 Fb2
Av1 Fp2
Av3 Fl-v3
RB 6
RB 5-6
RB 4-5
SC
DL
19
18
8
24
6
36
14
2

RIVER
MOSQUITO
Av1/Fl2
Av1/Fl2-3
Av1/Fl3
Av1/Fb4
Av2/Fb4
Av2/Fb5
Av2/Fb2
Av3/Fb5
Av3/Fl-v3
Av1/Fp2
RB/6
RB/5-6
RB/4-5
SC
36

INDEX MAP

LEGEND

Notations: Av1 ← Soil Symbol
Ft2 ← Topography Class
L ← Landform

Soil Symbol	Soil Classification	Parent Material	Dominant Texture	Drainage
Av1	Cumulic Humic and Orthic Humic Regosols	fluvial	loam to fine sandy loam	well
Av2	Orthic and Rego Dark Brown Chernozems	fluvial	loam	well
Av3	Orthic Humic Gleysols; Orthic Humic Regosols	fluvial	loam to fine	poorly

Miscellaneous Units:

RB - river banks: these steeply sloping units have variable soils and undifferentiated surficial material. Bedrock may occur at the surface especially in slumped areas.

SC - stream channels: this unit includes the stream and its adjacent banks.

GP - gravel pits

DL - disturbed lands: miscellaneous disturbed lands; i.e., roads, farmyards.

- small escarpments: this symbol was used to designate small escarpments on terraced landscapes. Slopes are generally Class 4 and do not severely limit cultivation.

- slumped: river banks that have slumped.

Topography Classes

Topo Class	Slope %	Description
2	0-2	very gently sloping
3	2-5	gently sloping
4	6-9	moderately sloping
5	10-15	strongly sloping
6	16-30	steeply sloping
7	31-45	very steeply sloping

Landforms

Genetic Material	Surface Expression
F - fluvial	b - blanket (over inclined)
	p - floodplain
	t - terraced
	t-z - gullied terrace
	u-z - undulating; gullied

1:20000

0 0.5 1 km

0 0.5 1 mile

ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 2.3

SURFICIAL GEOLOGY AND SOILS

LITTLE BOW RIVER BASIN - SITE 7B1

POTENTIAL RESERVOIR VOLUME : 62 000 000 m³

Prepared by PEDOCAN LAND EVALUATION LTD. for
BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

2.1.4 Site 7A

Site 7A includes most of Site 7B1 area, plus a section of the Little Bow River to the south. The soils and geology of the extension are similar to that described for Site 7B1, except for a minor area of saline Orthic Humic Gleysols just above the proposed 7A dam. All units are mapped in Figure 2.4 and summarized in Table 2.1.

2.2 Relative Impacts of Flooding

The effects of reservoir location on the soil resources of the four sites are evaluated in terms of:

- disinvestment in the agricultural land base;
- surface and slope stability at reservoir margins; and
- soil reclamation at dam construction sites.

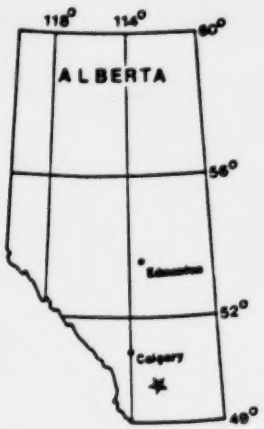
The order of presentation follows the perceived order of importance of the issues.

2.2.1 Loss of Agricultural Land Base

The agricultural capability of the proposed reservoir sites has been rated (see Table 2.1) using the Canada Land Inventory (CLI) system guidelines. The lands fall within CLI Capability Classes 3 to 6. Class 3 represents prime agricultural land (with certain management restrictions), Class 4 represents marginally arable land, Class 5 represents land suitable for use as improved pasture, and Class 6 represents land with limitations that restrict use to unimproved pasture.

Comparison of the extent of arable (as denoted by CLI criteria) agricultural land that will be flooded at the three sites (Table 2.2) shows that Site LB1 will flood approximately 245 ha, Site 2 approximately 50 ha, Site 7B1 approximately 470 ha., and Site 7A approximately 560 ha. The ratio of arable land flooded to total land

RIVER



INDEX MAP

LEGEND

Notations: Av1 ← Soil Symbol
Pt2 ← Topography Class
L ← Landform

Soil Symbol	Soil Classification	Parent Material	Dominant Texture	Drainage
Av1	Cumulic Humic and Orthic Humic Regosols	fluvial	loam to fine sandy loam	well
Av2	Orthic and Rego Dark Brown Chernozems	fluvial	loam	well
Av3	Orthic Humic Gleysols; Orthic Humic Regosols	fluvial	loam to fine	poorly
Av4	Orthic Humic Gleysols; saline	fluvial	loam	poorly

Miscellaneous Units:

RB - river banks: these steeply sloping units have variable soils and undifferentiated surficial material. Bedrock may occur at the surface especially in slumped areas.

SC - stream channel: this unit includes the stream and its adjacent banks.

GP - gravel pits

DL - disturbed lands: miscellaneous disturbed lands; i.e., roads, farmyards.

- small escarpments: this symbol was used to designate small escarpments on terraced landscapes. Slopes are generally Class 4 and do not severely limit cultivation.

- slumped: river banks that have slumped.

Topography Classes

Topo Class	Slope %	Description
2	0-2	very gently sloping
3	2-5	gently sloping
4	6-9	moderately sloping
5	10-15	strongly sloping
6	16-30	steeply sloping
7	31-45	very steeply sloping

Landforms

Genetic Material	Surface Expression	
F - fluvial	b	- blanket (over rolling or inclined
	p	- floodplain
	t	- terraced
	t-v	- gullied terrace
	u-v	- undulating; gullied

1:20000

0 0.5 1 km

0 0.5 1 mile

ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 2.4

SURFICIAL GEOLOGY AND SOILS

LITTLE BOW RIVER BASIN - SITE 7A

POTENTIAL RESERVOIR VOLUME: 62000000 m³

Prepared by PEDOCAN LAND EVALUATION LTD. for
BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

flooded (shown in Table 2.2) reveals that Site LB1 will lose the greatest amount of arable land relative to its size.

Table 2.2 Extent of Arable Land (CLI Classes 3 & 4) and Total Land Area in Reservoir Areas.

Area	Approx. Extent of Arable Land Flooded (ha)	Approx. Extent of Total Land Flooded (ha)	Ratio Arable Land: Total Land
Site LB1	245	328	1:1.3
Site 2	50	243	1:4.9
Site 7B1	470	1020	1:2.2
Site 7A	560	1060	1:1.9

Site 2 is a narrow valley with a narrow, linear floodplain that has wet, salinized soils in the valley bottom. The sandy arable soils occur on fluvial fans and aprons above the floodplains. Sites LB1, 7B1, and 7A have wide valleys with extensive terraces of good quality soils developed on deep fluvial sediments. Many acres are presently cultivated for grain or hay production and some irrigation systems are in place. Some of the best agricultural land is presently used for pasture.

A reservoir at Site 2 would flood the least amount of arable land, and most of this is Class 4, whereas almost all of the arable land that would be flooded at Sites LB1, 7B1, and 7A is higher value Class 3 land. A Site 2 reservoir will therefore cause the smallest loss in the agricultural land base. Sites 7B1 and 7A have the largest area of agricultural land and the most intensive agricultural development at present (see Section 3.0, Land Use).

2.2.2 Surface and Slope Stability

It has been assumed for the purposes of this study that the proposed reservoir shorelines would be formed by the steeply sloping banks of the Little Bow River or Squaw Coulee for almost the entire length of each shoreline. These slopes are very heterogeneous in their surficial materials, bedrock materials, and geomorphic processes. Materials, surface forms, and slope gradients change rapidly over short distances and are conventionally mapped as "River Bank" complexes (RB units on Geology-Soils Maps). Individual landform-soil units were not identified. Therefore evaluations of surface soil and slope stability can only be very general.

The geological materials that would form the reservoir edges include soft bedrock, fluvial-colluvial (slopewash) materials, and glaciolacustrine sediments. The proportions of each cannot be predicted with existing information.

Sites LB1, 7B1, and 7A have very similar geology and geomorphology (Table 2.1 and Maps). The river valley is incised into the soft mudstones of the Horseshoe Canyon Formation. The banks consist of exposed soft bedrock (saprolite) or thin veneers of fluvial and colluvial (slumped) materials overlying the soft bedrock. The textures of these materials tends to be loamy or clayey. They are highly erodible when exposed on slopes, and are sticky and unstable when wet.

Squaw Coulee (Site 2) is incised through the sandstones of the Porcupine Hills Formation. Hard sandstone outcrops occur in locations where the sandstone has resisted weathering. The slopes are not as steep as those of Sites LB1, 7B1, and 7A and are often blanketed by glaciolacustrine silts and clays on the upper slopes, and by fans and aprons of slopewash materials on lower slope positions. The soils at the proposed reservoir edge will be heterogeneous but will have predominantly clayey or loamy textures similar to those of the other two sites. Slopes at Site 2 will not be as steep as at Sites LB1 and 7B1, but slopes will be longer. The net result is that soil erosion hazard and surface stability is probably about equal at all sites.

Slope stability relates to slumps and other forms of soil mass-wasting. Thurber Consultants Ltd. (in W-E-R Engineering, 1985) conducted a geotechnical evaluation of Sites 1 and 2. They stated:

> "No significant concerns with respect to reservoir shoreline stability were identified..... Deep seated landslides are possible in all cases, however the frequency of occurrence of such landslides is expected to be very low. Shallow instability can be expected along the reservoir shorelines due to wave erosion. The beaches are expected to be self-stabilizing over 20 to 30 years". (p.i-ii)

It is expected that Sites 7B1 and 7A (which were not investigated by Thurber Consultants) would behave in a similar manner to Site LB1. Areas of rotational slumping have been identified on the Geology-Soils Map for all three sites (Figure 2.1 and Table 2.1). It is expected that such activity would continue. As Thurber Consultants stated, there appears to be little difference in slope stability among the sites.

2.2.3 Soil Reclamation at Dam Sites

Earth-fill embankments and borrow areas would be topsoiled and seeded to grass for erosion control (W-E-R Engineering, 1985). Accordingly, the soils have been evaluated in the areas of the dams and the remainder of the reservoir areas as to suitability of topsoil and subsoil for use in revegetation (Table 2.2) using Alberta Agriculture (1981) guidelines.

The soils at all four sites have similar quality for use as reclamation materials. Site 2 has the least quantity of topsoil available; however, availability has not been compared to requirements. Topsoil materials are rated Good or Fair quality, except for minor areas of saline soils on the floodplains of Sites LB1 and 7A. Subsoil ratings are the same as Topsoil ratings.

2.3 Summary

In some respects, the soils and surficial geology of the four proposed reservoir sites have common characteristics. No significant concerns have been identified at any of the sites with respect to soil erosion hazard or surface stability. The suitability of the topsoil and subsoil for reclamation purposes is also similar at all four sites. The variation in quantity of arable land, however, does permit identification of a preferred reservoir site. Site 2 would flood the least amount of arable land, followed by Sites LB1, 7B1, and 7A. As well, most of the arable land at Site 2 is of poorer quality than the arable land at the other two sites. This is reflected in the area of land presently cultivated and in the range of crops grown. Sites LB1, 7B1, and 7A have many hectares presently cultivated in grain, oil seeds, or hay, and some irrigation systems are in place. Site 2 is primarily pasture. Land use is reviewed in more detail in Section 3.0 of this report.

2.4 Data Gaps

The interpretation of soils at the three proposed reservoir sites was based on interpretation of airphotos, with cursory field checking. While this is sufficient for an overview level of planning, more detailed studies will be required at later planning stages. Detailed studies are especially needed to accurately determine bank stability at the reservoir sites. This investigation should be undertaken by a geotechnical engineer.

3.0 LAND USE

The primary land use in the area of the four potential reservoir sites is agriculture, composed of dryland farming, irrigation farming, and ranching. Other land uses include roads, sand and gravel extraction, cemeteries, and farmsteads. Historical resources also exist at all reservoir sites, including buffalo jumps, Indian encampments, tee-pee rings, trading posts, and homesteads. Only the most noteworthy of these are included in this report since the compilation of cultural information was beyond the scope of this study. Historical and paleontological concerns of the four reservoir sites have been addressed by the Archeological Survey of Alberta. Land use information for the four sites was obtained from 1:10,000 scale air photos and from a two-day field reconnaissance conducted on October 31 and November 1, 1985. The information obtained from the air photos and field inspection was recorded on 1:20,000 scale photomosaics for each reservoir site.

3.1 Existing Land Uses

The percentage of land in each major land use category was determined for each potential reservoir site using a grid overlay technique on the 1:20,000 scale photomosaics (plus or minus 5% standard error). The percentages and corresponding areal coverages are shown in Table 3.1. It should be noted that native land, presented in the table, refers to any natural area that is not used for an agricultural purpose. Native land areas are located primarily in regions of adverse terrain along the stream banks or river valley slopes. In addition to the land use percentages, the numbers of specific land uses at the four sites were recorded (Table 3.2).

Licensed surface water use for the three potential reservoir sites is presented in Table 3.3. The licenses are primarily for irrigation although one water license is for municipal use and one for domestic use. Public Lands information for each reservoir site is shown in Table 3.4. This information was acquired from the Land Status Automated System (LSAS) Public Standing Report, which contains information specific to all Energy and Natural Resources interests on land in the Province of Alberta. The percentages and numbers of the various land uses are discussed for each site in the following sections.

Table 3.1 Areal Extent of Major Land Uses at Four Potential Reservoir Sites in the Little Bow River Basin

Site	Pasture	Improved Pasture[a]	Cropland	Irrigated Cropland	Native Land		Non-Agricultural Land	Total Land Area
					Stream	Upland		
LB1	28% 92 ha	2% 7 ha	27% 89 ha	9% 30 ha	21% 69 ha	8% 25 ha	5% 16 ha	328 ha
2	75% 182 ha	0% 0 ha	6% 15 ha	0% 0 ha	11% 27 ha	1% 2 ha	7% 17 ha	243 ha
7B1	49% 500 ha	1% 10 ha	18% 183 ha	9% 92 ha	16% 163 ha	4% 41 ha	3% 31 ha	1020 ha
7A	39% 413 ha	1% 11 ha	24% 254 ha	7% 74 ha	19% 201 ha	6% 64 ha	4% 43 ha	1060 ha

[a] Improved pasture is considered to be an area that has been broken and seeded for pasture or a former cultivated area which has been seeded back to pasture.

Table 3.2 Number of Specific Land Uses at Four Potential Reservoir Sites in the Little Bow River Basin

Site	Roads	Farm-steads	Non-Residential Farm bldg.,etc.	Transmission Lines		Sand & Gravel Extraction	Oil & Gas Wells	Other
				Power	Oil & Gas			
LB1	1	2	5	0	0	1	0	
2	3	1	0	0	0	1	0	1 buffalo jump 1 indian encampment
7B1	3	4	0	0	1	1	0	2 pumphouses 1 cemetery 1 reservoir
7A	4	6	1	1	1	1	0	2 pumphouses 1 cemetery 1 reservoir

Table 3.3 Licensed Surface Water Use at Four Potential Reservoir Sites in the Little Bow River Basin

Site/No.	Land Location	Applicant Name	Source Supply	Stat. Purpose	Spec. Purpose
LB1-1	NE32-017-27-4	Hut.Br.High River	Little Bow R.	Irr	39[a]
LB1-2	SW02-018-28-4	Coote, Donald H.	Little Bow R.	Irr	39
		Akitt, B. & J.	Little Bow R.	Irr	39
		Akitt, B. & J.	Little Bow R.	Dom	40[b]
LB1-3	SE02-018-28-4	Calvert, Robert K.	Little Bow R.	Irr	39
LB1-4	NW03-1-018-28-4	Akitt, B. & J.	Little Bow R.	Irr	39
LB1-5	NE03-1-018-28-4	Giles, Donald R.	Little Bow R.	Irr	39
2-1	NE16-018-29-4	Perrott, James R.	Squaw Coulee	Irr	39
7B1-1	NE07-015-25-4	Mallory, Donald	Little Bow R.	Irr	39
7B1-2	SE07-015-25-4	Flitton, Wilma May	Little Bow R.	Irr	39
7B1-3	SW07-015-25-4	Jones, Eldon L.	Mosquito Cr.	Irr	39
7B1-4	SE07-015-25-4	Flitton, Gary R.	Mosquito Cr.	Irr	39
7B1-5	SW08-015-25-4	Carnegie, Buster D.	Little Bow R.	Irr	39
7B1-6	SW11-015-26-4	Ohler, Rodger	Mosquito Cr.	Irr	39
7B1-7	SE12-015-26-4	Monkman Ranch	Mosquito Cr.	Irr	39
7B1-8	NE12-015-26-4	Clopton, D & J	Little Bow R.	Irr	39
7B1-9	NE13-015-26-4	Hut.Br.Little Bow	Little Bow R.	Irr	39
7B1-10	NW13-015-26-4	Flitton, Gary R.	Little Bow R.	Irr	39
7B1-11	SE13-015-26-4	Hut.Br.Little Bow	Little Bow R.	Mun	49[c]
7B1-12	NW23-015-26-4	Jorgens, John R.S.	Trib to L. Bow	Irr	39
7B1-13	SW26-015-26-4	Dykstra, Adrian A.	Little Bow R.	Irr	39
		Egger, George N.	Little Bow R.	Irr	39
7B1-14	NE34-015-26-4	Egger, George N.	Little Bow R.	Irr	39
7B1-15	NW34-015-26-4	Berger, Jacob H.	Little Bow R.	Irr	39
7B1-16	NE35-015-26-4	Brown, Eric K.	Little Bow R.	Irr	39
7B1-17	NW35-015-26-4	Keith Fischer Farms	Little Bow R.	Irr	39
7B1-18	SE04-016-26-4	Dykstra, Adrian A.	Little Bow R.	Irr	39

Table 3.3 **Licensed Surface Water Use at Four Potential Reservoir Sites in the Little Bow River Basin** Concluded

Site/No.	Land Location	Applicant Name	Source Supply	Stat. Purpose	Spec. Purpose
7B1-19	SW09-016-26-4	Lievaart, Job	Little Bow R.	Irr	39
7B1-20	SW10-016-26-4	Steeby, Darrell C.	Little Bow R.	Irr	39
7A-1	NE07-015-25-4	Mallory, Donald	Little Bow R.	Irr	39
7A-2	SE07-015-25-4	Flitton, Wilma May	Little Bow R.	Irr	39
7A-3	SW07-015-25-4	Jones, Eldon L.	Mosquito Cr.	Irr	39
7A-4	SE07-015-25-4	Flitton, Gary R.	Mosquito Cr.	Irr	39
7A-5	SW08-015-25-4	Carnegie, Buster D.	Little Bow R.	Irr	39
7A-6	SW11-015-26-4	Ohler, Rodger	Mosquito Cr.	Irr	39
7A-7	SE12-015-26-4	Monkman Ranch	Mosquito Cr.	Irr	39
7A-8	NE12-015-26-4	Clopton, D & J	Little Bow R.	Irr	39
7A-9	NE13-015-26-4	Hut.Br.Little Bow	Little Bow R.	Irr	39
7A-10	NW13-015-26-4	Flitton, Gary R.	Little Bow R.	Irr	39
7A-11	SE13-015-26-4	Hut.Br.Little Bow	Little Bow R.	Mun	49[c]
7A-12	NW23-015-26-4	Jorgens, John R.S.	Trib to L. Bow	Irr	39
7A-13	SW26-015-26-4	Dykstra, Adrian A.	Little Bow R.	Irr	39
		Egger, George N.	Little Bow R.	Irr	39
7A-14	NE34-015-26-4	Egger, George N.	Little Bow R.	Irr	39
7A-15	NW34-015-26-4	Berger, Jacob H.	Little Bow R.	Irr	39
7A-16	NE35-015-26-4	Brown, Eric K.	Little Bow R.	Irr	39
7A-17	NW35-015-26-4	Keith Fischer Farms	Little Bow R.	Irr	39

[a] specific purpose 39 = general agriculture use (irrigation of cropland)
[b] specific purpose 40 = stockwatering
[c] specific purpose 49 = community water

Source: Alberta Environment Water Resources Administration Division, and Surface Water Rights Branch (computer printout dated Nov. 13, 1985)

Table 3.4 Public Lands Information for Four Potential Reservoir Sites in the Little Bow River Basin

Site	Land Location	Status Code	Activity[a]	Client	Area (ha)
LB1	SE-03-18-28W4	disposition	Roadway	Prov. of Alta	1.45
	NW-03-18-28W4	approved	Protective Notation[b]	Alta. E. & N.R.	76.40
	NW-03-18-28W4	disposition	Grazing Lease	B.J. Akitt	76.40
	NE-03-18-28W4	disposition	Roadway	Prov. of Alta.	5.35
2	NE-16-18-29W4	approved	Irrigation Structure	Alta. Env.	21.96
	NW-34-17-29W4	disposition	Roadway	previous church site	0
7B1	NE-12-15-26W4	disposition	Roadway	Prov. of Alta.	3.16
	SE-13-15-26W4	disposition	License of Occupation	Hutterite Church	.02
	SE-13-15-26W4	disposition	Pipeline Agreement	L. Bow Gas Co-op	.14
	NW-35-15-26W4	disposition	License of Occupation	Town of Vulcan	.12
7A	NE-12-15-26W4	disposition	Roadway	Prov. of Alta.	3.16
	SE-13-15-26W4	disposition	License of Occupation	Hutterite Church	.02
	SE-13-15-26W4	disposition	Pipeline Agreement	L. Bow Gas Co-op	.14
	NW-35-15-26W4	disposition	License of Occupation	Town of Vulcan	.12
	SE-29-14-24-W4	disposition	Rural Electrivication	Alta. E. & N.R.	155.00

a Due to the recent activation of the LSAS reports, some of the information on roadways may not be entirely complete (i.e., some public roads that exist at the sites may not be recorded above); however, all other information should be up-to-date.

b The protection notation indicates that the land has been reserved by Alberta Energy and Natural Resources as a potential recreation area.

Source: Alberta Energy and Natural Resources LSAS (Land Status Automated System) Public Standing Report - computer printout dated November 19, 1985

3.1.1 Site LB1

Approximately two thirds of the land at Site LB1 is currently being used for agricultural purposes, 30% as pasture and 36% as cropland (see Table 3.1). Nine percent of the cropland is currently under irrigation. The cultivated areas are small and irregularly shaped due to the meandering nature of the stream bed and valley bottom. Approximately 30% of the land is considered native although 21% of that amount is taken up by the stream bed itself. Site LB1 has the highest amount of cropland and native land relative to its overall size (see Table 3.1). The most significant non-agricultural lands include two farmsteads and a county road. The areal extent of Site LB1 is slightly larger than Site 2 and just over one third the size of Sites 7B1 and 7A.

There are five active surface water licenses within the boundaries of Site LB1, four being used for irrigation purposes and one for domestic water use. Concerning public lands, there is one roadway disposition which runs through two quarter sections, one grazing lease, and a small area protected by Alberta Public Lands for its recreational potential.

Additional comments about the land use of Site LB1 are as follows:

- the gravel pit does not appear to be currently in use;
- of the two farmsteads situated in the valley bottom, one is small (one small farmhouse and a barn) and one is medium-sized (large farmhouse, large barn, and a number of equipment sheds);
- of the five non-residential farm dwellings listed in Table 3.2, two are hay barns, one is a large barn and quonset hut, one is a large abandoned barn, and one is a grain storage yard owned by a nearby Hutterite Colony;
- the grain storage yard (discussed above), which contains one or two sheds and a number of grain storage containers, may or may not be affected by reservoir flooding depending on the exact placement of the dam itself;

- the native land areas are located primarily on the north-facing slopes where the steepness of terrain and shrub density does not permit other land uses;

- a small strip of native riparian vegetation exists along the shoreline of the Little Bow River but usually consists of only a few grasses or occasional low lying shrubs; and

- the road which travels north-south through the upper reach of Site LB1 has a gravel surface.

The areal extent of various land uses at Site LB1 are provided in Figure 3.1. Photographs of the site are presented as Plates 3.1 A, B, C, and D.

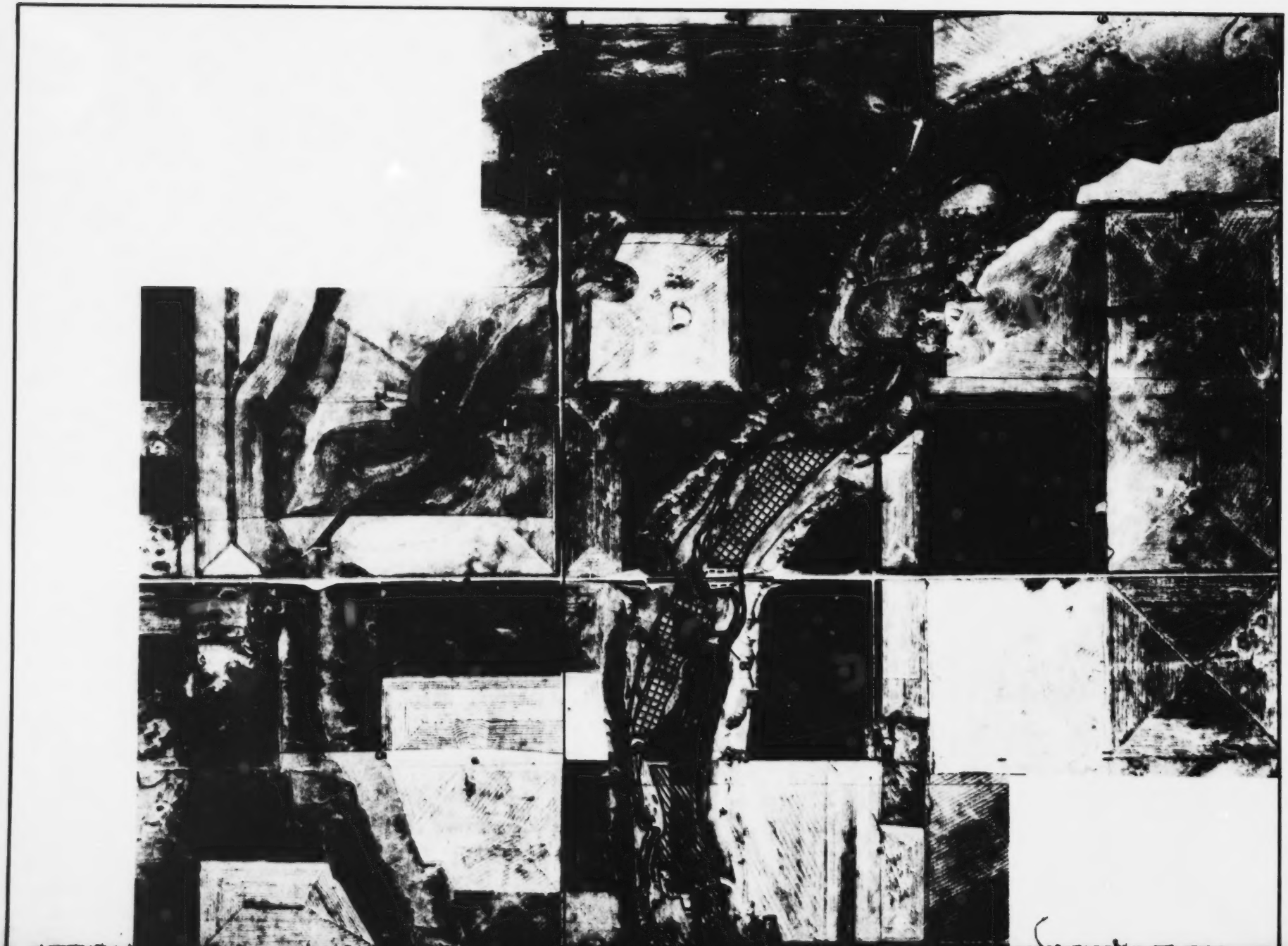
3.1.2 Site 2

Almost 75 percent of the land at Site 2 is used for pasture and only 5% is under cultivation. There is no improved pasture or irrigated cropland within the site boundaries. Twelve percent of Site 2 is classed as native land; however, virtually all of the native land is situated in the stream bed itself. This absence of upland native land is largely due to the reduced steepness of the river valley slopes (as compared with Sites 1, 7B1, and 7A), which permits the land to be put to agricultural use. One farmstead is situated in the river valley at this site. There is only one licensed surface water withdrawal occurring in Site 2 and it is for water storage purposes. Public Lands records reveal one public roadway and one water control structure (Squaw Coulee reservoir) within the boundary of Site 2. Two additional roadways, a buffalo jump, and an Indian encampment are also present at Site 2, although they are not present on the Public Lands records.

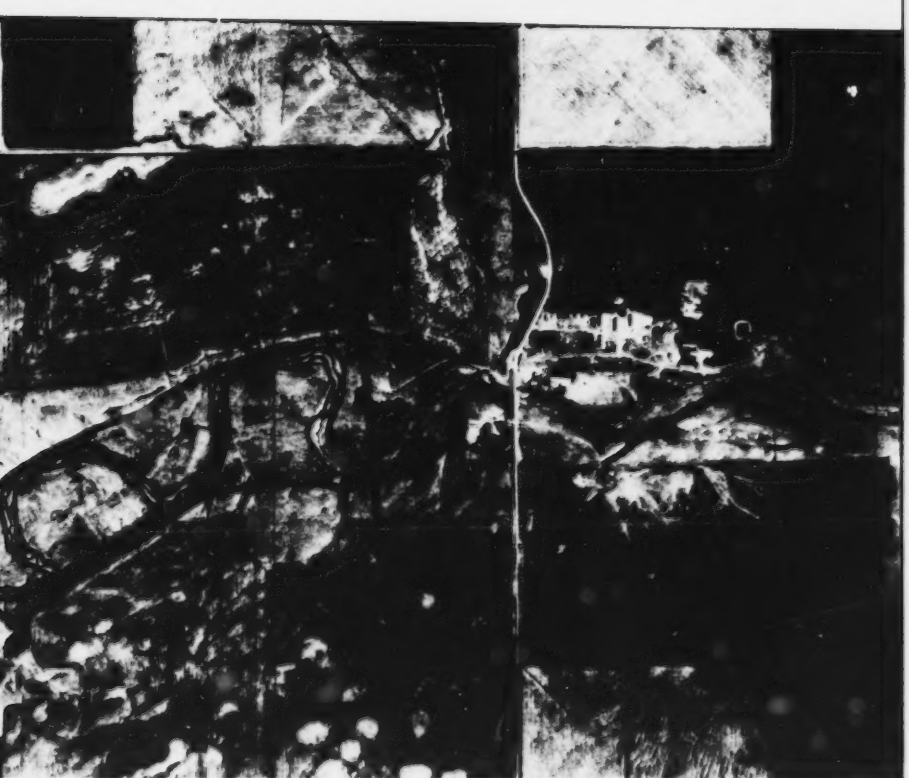
Additional comments about the land use of Site 2 are as follows:

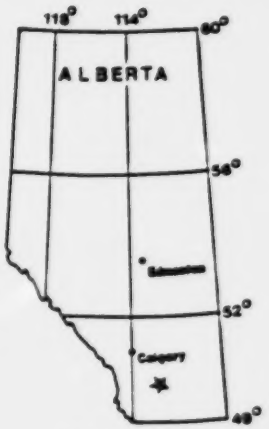
- the gravel pit shows signs of recent excavations;

- the single farmstead in Site 2 is large in size and is situated at a substantially higher elevation than the Squaw Coulee stream bed;



FSL at 3290 feet





INDEX MAP

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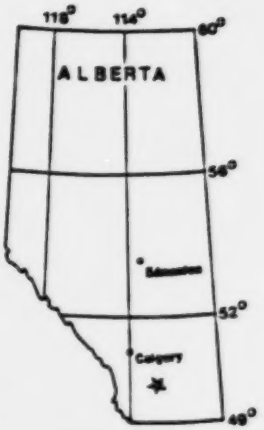
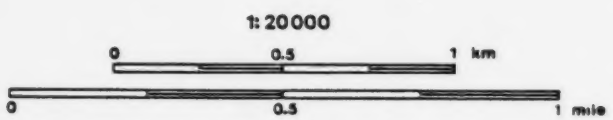


INDEX MAP

LEGEND

- Pasture
- Improved Pasture
- Irrigated Pasture
- Cropland
- Irrigated Cropland
- Stream Channel
- B - Building(s)
- Gravel Pit
- Main Road
- Private Road
- Stream Crossing
- Native Land
- Sandstone Outcrop
- Marshy Area
- Eroded Area
- Cemetery
- Transmission Line



ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 3.1

LAND USE

LITTLE BOW RIVER BASIN – SITE LB1

POTENTIAL RESERVOIR VOLUME : 21 000 000 m³

BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

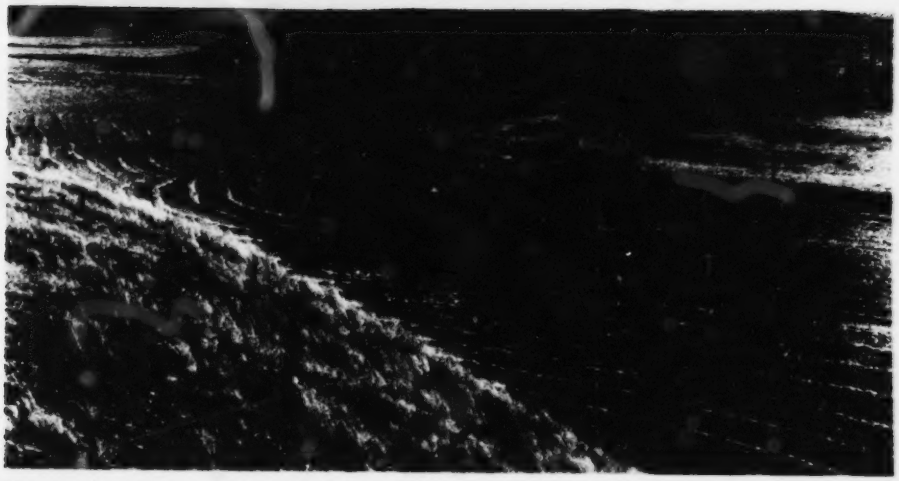


Plate 3.1 A Central portion of Site LB1 looking southeast. Note the extensive areas of cultivation in the river valley bottom and the shrub and tree vegetation on the steep, north facing slope.

Plate 3.1 B Little Bow River in central portion of Site LB1. Note submergent and emergent vegetation in streambed.

Plate 3.1 C Downstream portion of Site LB1 (dam site) looking west. Note extensive instream vegetation and steepness of river valley slopes.

Plate 3.1 D Upstream portion of Site LB1 looking west. Note berry bushes in foreground and vegetative cover on north facing slope in background.

- the Old Woman buffalo jump is situated between two sandstone outcrops on the north facing slope of Squaw Coulee;

- the Historic Site (Indian Encampment) situated in the valley bottom adjacent to the above-mentioned buffalo jump shows signs of recent archeological excavations for Indian artifacts;

- there are a number of small bridges and/or road and culvert crossings along the Squaw Coulee stream;

- there is virtually no shrub vegetation in Site 2 and there is minimal riparian vegetation along the Squaw Coulee stream;

- there is no shoreline vegetation in the northern portion of Site 2 due to stream channelization;

- the existing PFRA Squaw Coulee reservoir (now owned by Alberta Environment) is situated at the northern end of Site 2; and

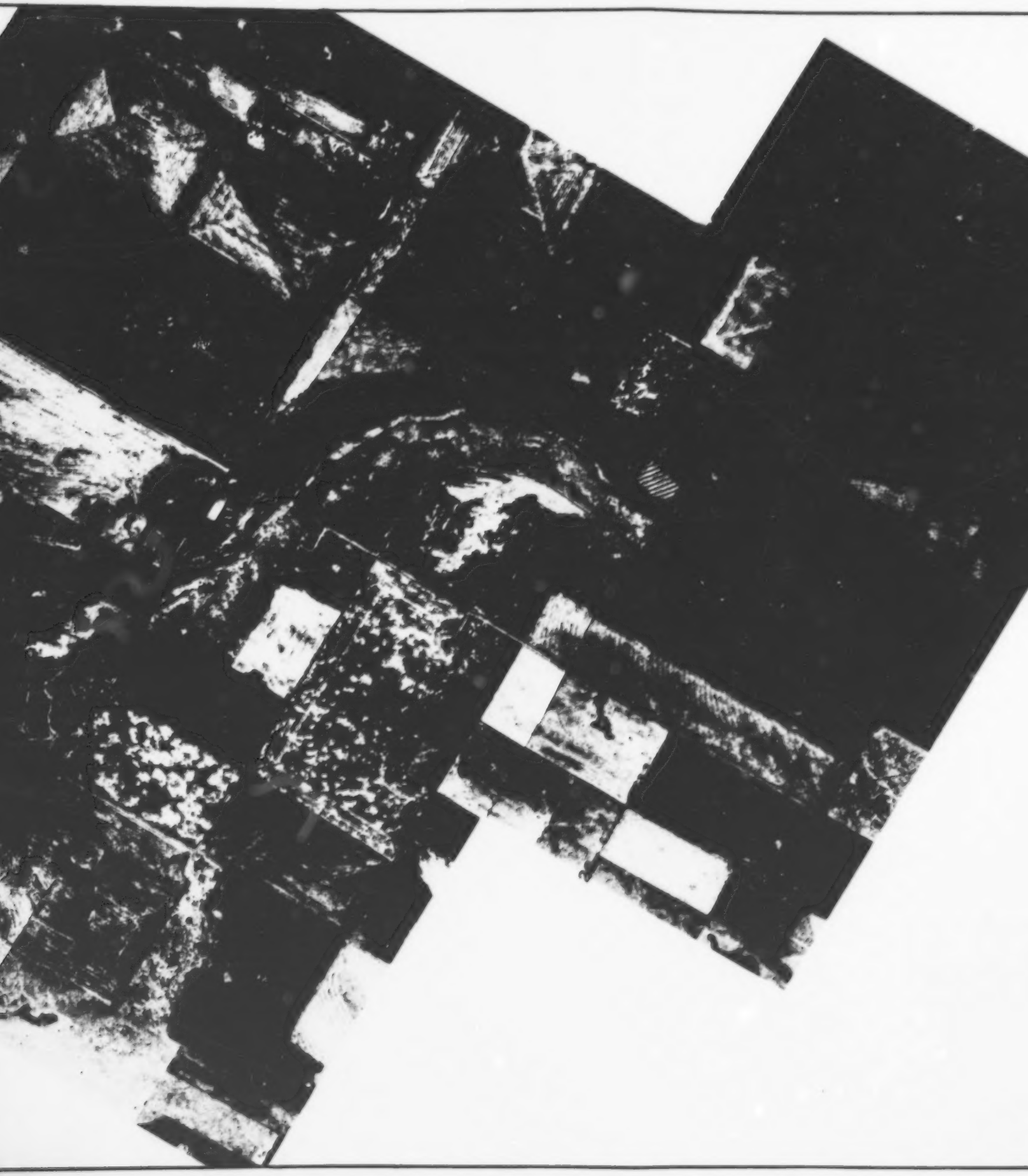
- the two roads in the northern end of Site 2 have gravel surfaces whereas the road which runs through the center of Site 2 has a gravel-asphalt mix surface.

Land uses for Site 2 are mapped in Figure 3.2. Particular land use features at the site are illustrated in Plates 3.2 A, B, C, and D.

3.1.3 Site 7B1

Approximately half of the land at Site 7B1 is used for pasture; 1 percent of which is improved pasture (see Table 3.1). Twenty-seven percent of Site 7B1 is cropped with 9 percent of that cropland being under irrigation. Native land makes up 20 percent of the land use; however, 16 percent of that amount is along the stream banks. Concerning non-agricultural land, three roads, an underground pipeline, three farmsteads, and the Little Bow Hutterite colony are of primary importance.

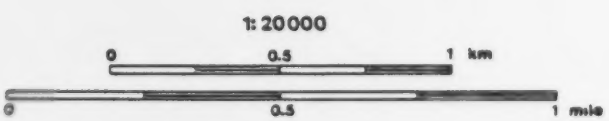
DUGOUT



INDEX MAP

LEGEND

- Pasture
- Improved Pasture
- Irrigated Pasture
- Cropland
- Irrigated Cropland
- Stream Channel
- B - Building(s)
- Gravel Pit
- Main Road
- Private Road
- Stream Crossing
- Native Land
- Sandstone Outcrop
- Marshy Area
- Eroded Area
- Cemetery
- Transmission Line



ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 3.2

LAND USE

LITTLE BOW RIVER BASIN - SITE 2

POTENTIAL RESERVOIR VOLUME : 18 000 000 m^3

BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

Plate 3.2 A Downstream portion of Site 2 (dam site) looking north. Note stream morphology and lack of upland vegetative cover.

Plate 3.2 B Old Woman Buffalo Jump in central portion of Site 2 looking south. Note sandstone outcrops on slopes and midden of buffalo bones in foreground.

Plate 3.2 C Central portion of Site 2 (near buffalo jump) looking southeast. Note wet terrain in river valley and lack of vegetative cover.

Plate 3.2 D Upstream portion of Site 2 looking north to PFRA dam. Note channelized stream and salt deposits along banks.

At the time of this study, there were 20 licensed water users drawing water from the Little Bow River or Mosquito Creek at Site 7B1. All of the water withdrawals were for irrigation except for one municipal withdrawal to the Town of Vulcan. Concerning public lands, there was one roadway disposition recorded (although three roadways were present at the site), one disposition for a municipal pumphouse, one license of occupation for a Hutterite church, and one disposition for a pipeline near the Hutterite Colony.

Additional comments about the land use of Site 7B1 are as follows:

- it is unknown whether or not the gravel pit adjacent to Mosquito Creek is presently being used;

- of the four farmsteads listed in Table 3.2, two are large farms with numerous buildings, one is an abandoned farmhouse, and one is a large Hutterite colony;

- the Hutterite colony mentioned above has more than eight large residential/farm dwellings as well as a large hog barn which is situated on the top of the Little Bow River bank;

- a small fenced cemetery area is situated in the valley bottom, within the boundaries of the Hutterite colony; however, no deceased have yet been buried there;

- the two pumphouses situated within Site 7B1 serve the Town of Vulcan and the Hutterite Colony;

- secondary banks immediately adjacent to the Little Bow River and Mosquito Creek in the terraced areas of Site 7B1 permit the establishment of riparian vegetation since they are less accessible to grazing cattle;

- native land areas are restricted primarily to the river valley slopes in regions of excessively steep terrain;

- stands of dense shrubs or arboreal vegetation are more prevalent on north-facing slopes where moisture loss is not as high;

- four fields of irrigated cropland exist within the valley bottom of Site 7B1; and

- of the three roads which traverse Site 7B1, the most northern road is gravel, the road passing the Hutterite Colony is improved gravel with some paved sections, and the road traversing Mosquito Creek has a dirt surface.

The land uses at Site 7B1 are mapped in Figure 3.3. Photographs corresponding to particular land uses at this site are presented in Plates 3.3 A, B, C, D, E, and F.

3.1.4 Site 7A

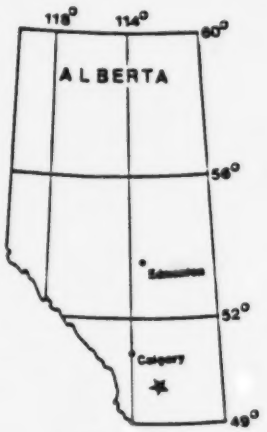
Due to the large area of overlap between Sites 7B1 and 7A, the land uses of the two sites are somewhat similar. Approximately 40 percent of the land at Site 7A is used for pasture. Cropland occurs over 31 percent of the land at this site, of which 7 percent is irrigated. Native land comprises 25 percent of total land use with over three-quarters of that amount being confined to the stream banks. Three roads, an underground pipeline, an overhead transmission line, four farmsteads, and the Little Bow Hutterite Colony make up the primary non-agricultural land uses.

Seventeen licensed surface water users draw water from the watercourses at Site 7A. There are no active licensed surface water users south of the 7B1 dam site at Site 7A. Public lands information is similar to Site 7B1, except for an additional roadway and rural electrification route (power transmission line).

Comments concerning the land use of Site 7A, not mentioned in the comments section for Site 7B1, are as follows:

- the stream channel downstream of the 7B1 dam site narrows significantly, in comparison with the upstream portion, and thus causes a significant reduction in streambank vegetation;

CREEK
DUGOUT
FLOODED



INDEX MAP

LEGEND

- Pasture
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- Stream Channel
- B - Building(s)
- Gravel Pit
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- Private Road
- Stream Crossing
- Native Land
- Sandstone Outcrop
- Marshy Area
- Eroded Area
- Cemetery
- Transmission Line

1:20000

0 0.5 1 km

0 0.5 1 mile

ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 3.3

LAND USE

LITTLE BOW RIVER BASIN - SITE 7B1

POTENTIAL RESERVOIR VOLUME: 62 000 000 m^3

BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

Plate 3.3 A Upstream portion of Site 7B1 looking southwest. Note extensive cultivation in river valley bottom. Also note irrigation pump site and shrub vegetation on slopes.

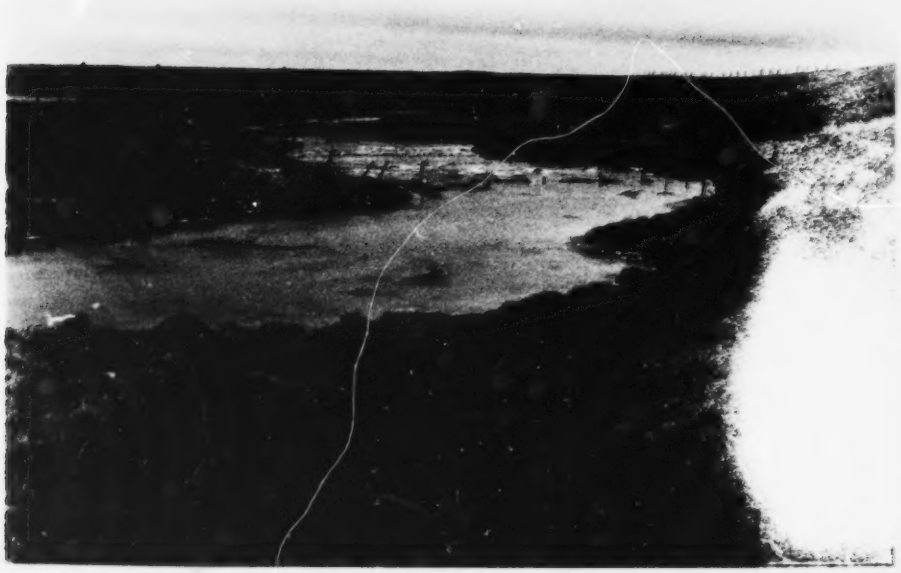


Plate 3.3 B Little Bow River in upstream portion of Site 7B1 looking east. Note stream morphology and bank characteristics.

Plate 3.3 C Town of Vulcan pumping station in upper-central portion of Site 7B1 looking southeast. Note area of potential slumping and erosion in background.

Plate 3.3 D Little Bow Hutterite Colony in lower-central portion of Site 7B1 looking northwest. Additional buildings owned by the Colony are present to the immediate right of the photograph.

Plate 3.3 E Swan staging area in central portion of Site 7B1 looking west. Note increased stream width and extensive shoreline vegetation at this location.

Plate 3.3 F Upstream portion of Mosquito Creek at Site 7B1 looking west. Note washed out beaver dam and extensive shrub vegetation on slopes and river valley bottom. This reservoir reach represents the primary area for wildlife at Site 7B1.

- the steep north facing slopes at the south end of Site 7A provide one of the better regional habitats in terms of food and cover;

- the Fireguard Road traversing the south portion of Site 7A has a gravel surface; and

- an overhead power transmission line crosses the river valley in a north-south direction a short distance downstream of the Fireguard Road.

Figure 3.4 provides a map of the land uses occurring within Site 7A. Photographs relevant to the southern portion of Site 7A (i.e. downstream of the 7B1 dam site) are provided as Plates 3.4 A and B.

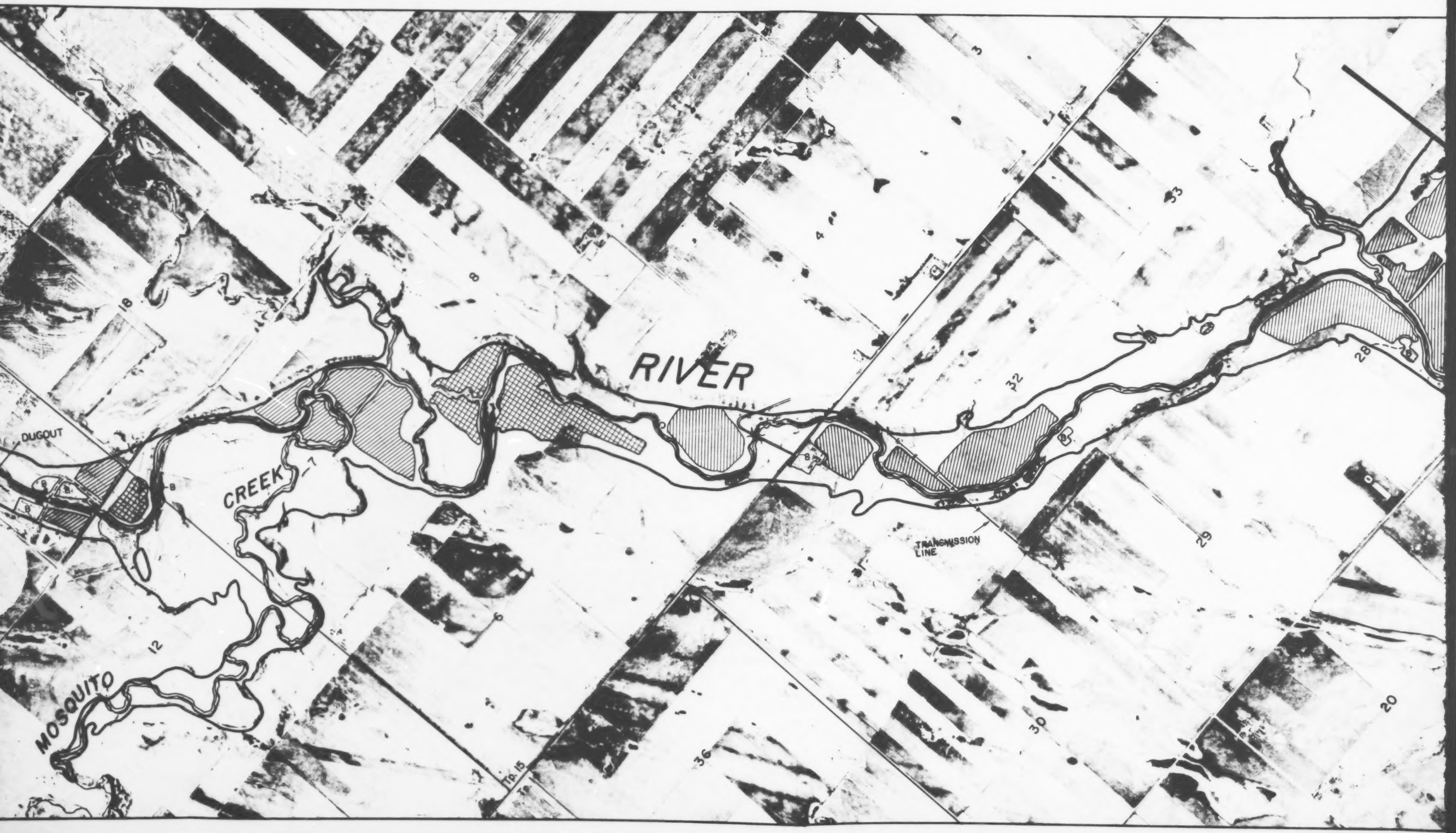
3.2 Relative Impacts of Flooding

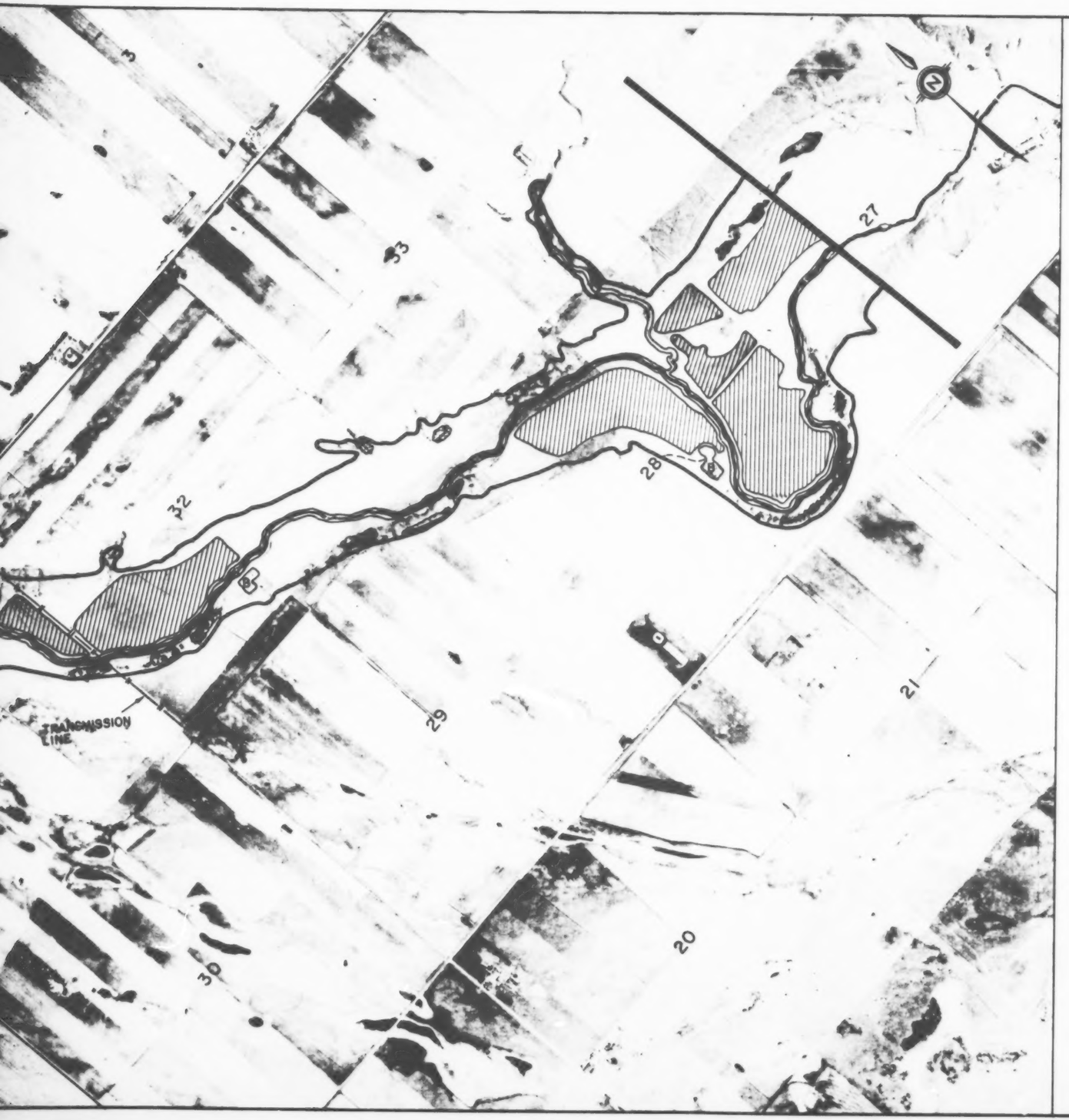
If each type of land use occurring at the four reservoir sites were to be assigned an equal value, then the size of each reservoir alone would determine which site would suffer the greatest impact due to flooding. In other words, given that the land value per unit area was the same for each site, the largest site would receive the greatest impact rating since a larger area of equal value land would be flooded. In reality, however, certain land areas have a greater value than others, either because of their differing economic value or uniqueness. Therefore, in order to more accurately determine which reservoir site will have the greatest land use impact due to flooding, it is necessary to assign a relative value or weighting to each type of land use. All of the various land uses have been grouped into four broad categories and are assigned a relative weighting as follows:

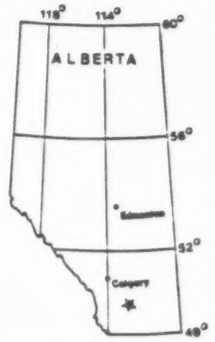
Land Use Category	Weighting
Pasture	1
Native Land (vegetated areas)	2
Cropland	3
Non-Agricultural Land (buildings, roads, etc)	20

16
17
Tp. 16
15

6
9
18
24
W
DUGOUT
CREE
MOSQUITO
12


RIVER
CREEK
MOSQUITO
DUGOUT
TRANSMISSION LINE
18
8
4
3
33
32
28
29
12
6
36
30
20
Tp. 15





INDEX MAP

LEGEND

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- Private Road
- Stream Crossing
- Native Land
- Sandstone Outcrop
- Marshy Area
- Eroded Area
- Cemetery
- Transmission Line

1:20000

0 0.5 1 km

0 0.5 1 mile

ALBERTA ENVIRONMENT PLANNING DIVISION

Figure 3.4

LAND USE

LITTLE BOW RIVER BASIN - SITE 7A

POTENTIAL RESERVOIR VOLUME: 62 000 000 m^3

BEAK ASSOCIATES CONSULTING LTD.

SCALE 1:20000	DATE FEBRUARY, 1986

Plate 3.4 A Downstream portion of Site 7A immediately below 7B1 dam site looking south. Note channel configuration and power transmission line traversing river valley in background.

Plate 3.4 B Downstream portion of Site 7A looking west. Note agricultural development in river bottom and vegetative cover on slopes.

It should be emphasized that this ranking is highly subjective, representing only an "educated guess" at the relative value of each land use category. In general terms, cropland has been assigned a weight three times larger than pasture due to the estimated economic yield of cropland (per unit area) over pasture. Native land has been assigned a weighting larger than pasture but less than cropland because certain landowners have opted to leave land suitable for pasture in its natural state. Their reasons for not developing the land include interest in wildlife viewing, nature appreciation, and aesthetically pleasing picnic and recreation sites as well as a desire to maintain good quality berry picking sites. Native land has also been assigned a slightly higher value than pasture because of its relative scarcity in the region and in recognition of the critical habitat it provides for wildlife. Non-agricultural land, which groups together roads, barns, farmsteads, etc., has been assigned the highest value due to the relative cost of establishing these lands and the economic impact of flooding them.

The above mentioned weightings were multiplied by the areal extent of each land use category and by a constant (.01) to reduce the overall size of the resultant figures. These areal extents and weighted values are provided in Table 3.5.

Table 3.5 Approximate Amount and Weighting of Land in Four Land Use Categories at Four Potential Reservoir Sites in the Little Bow River Basin

	Pasture		Cropland		Native Land		Non-Agr. Land		Total Area	Total Weighted
Site	ha	WV	ha	WV	ha	WV	ha	WV	ha	Value
LB1	99	1.0	119	3.6	94	1.9	16	3.2	328	9.7
2	182	1.8	15	0.5	29	0.6	17	3.4	243	6.3
7B1	510	5.1	275	8.3	204	4.1	31	6.2	1020	23.7
7A	424	4.2	328	9.8	265	5.3	43	8.6	1060	27.9

WV = Weighted Value

The total weighting values shown in Table 3.5 reveal that 7A would be most vulnerable to land use impacts, with similar but slightly lesser impacts being associated with Site 7B1. Significantly fewer impacts would occur at Site LB1, and the least impacts would occur at Site 2. If a weighting had not been assigned to each land use category, the ranking would have been the same. For this reason, it appears that the areal extent of each reservoir site is the predominant factor in determining which site will be most heavily impacted by flooding from a land use standpoint. Once again it should be emphasized that, due to the subjectivity of the weighting system, the final weighting values shown in Table 3.5 should not be given any significance beyond their usefulness in obtaining a final ranking of the four sites.

Some potential effects of flooding that apply to all four sites are as follows:

Detrimental

- farmers' fields in the upper reaches of the reservoir may become severely divided;
- extensive mudflats would be exposed during low periods in the upper reaches of the reservoir;
- substantial native land which provides cover for wildlife would be lost;
- farmsteads, barns, pumphouses, etc., would be flooded or would have to be moved to other locations;
- the flooded banks may cause severe erosion and slumping in local areas, thereby bringing about land areas with no land use; and
- roads and bridges would be flooded causing significant detours unless new roads and bridges were built to replace flooded ones.

Beneficial

- numerous acres of land in the upland areas adjacent to the reservoir sites could be opened up for irrigation farming;

- downstream water users would be guaranteed more evenly distributed flows throughout the growing season;

- if new roads are built to replace flooded roads (thereby providing access to the reservoir sites), recreation areas for swimming, boating, and fishing could be developed adjacent to the reservoirs. (It should be noted that reservoir level fluctuations would put substantial limitations on recreation development); and

- possible replacement of wildlife habitat in areas where land areas have become severely divided or fragmented and are of no agricultural value.

3.3 Summary

Taking into account all agricultural land, native land, and non-agricultural land, Site 7A would be most vulnerable to flooding-related land use impacts. Slightly fewer land use impacts would be expected to occur at Site 7B1. Site LB1 would be approximately one third as vulnerable to land-use impacts as Sites 7A and 7B1, primarily due to a significant reduction in reservoir size. Site 2 is rated as having the least impacts (approximately one-quarter of the impacts at Sites 7B1 and 7A), owing to its small reservoir size and lack of high value land uses. The areal extent of land flooded at each reservoir site appears to be the primary factor in determining total land use impacts. Site LB1 would have the greatest land use impact relative to its size, resulting from a comparatively higher percentage of native land and cropland.

In terms of non-agricultural land, the most significant losses in the area of Site LB1 would be the flooding of two farmsteads, both of which are situated in the river bottom. At Site 2, the most significant losses would be the possible

flooding of one farmstead and the flooding of two historic sites: a buffalo jump and an Indian encampment. The major losses at Site 7B1 would be the flooding of two large farmsteads and a Hutterite colony. Site 7A would have the same losses as Site 7B1, as well as an additional farmstead.

3.4 Data Gaps

It is not clear exactly how much additional land above the maximum flood-line around the reservoir will be acquired by the Government and to what uses that land will be put. For instance, will cattle be permitted to use the reservoir as a source of stockwater, or will the reservoir be fenced off? Will areas of vegetative cover on steep terrain be stabilized to avoid slumping into the reservoir? Will berms or dikes be built at the upstream end of the reservoir to protect high value land areas and reduce the amount of mudflats? Only after it has been firmly established exactly how much land will be flooded and/or altered at the reservoir site will it be possible to provide an accurate assessment of land use impacts.

4.0 WATER QUALITY *

This section predicts the water quality that might be expected in the four alternate reservoir sites in the Little Bow Basin. Since these reservoirs would be filled with water from the Highwood River, the existing quality of that river at the proposed points of diversion is presented, as is the present quality of water in the Little Bow Basin. The effect of a reservoir on downstream water quality is also discussed.

4.1 Data Base

This section was based on existing data and reports. The data for the Little Bow Basin was collected by Alberta Environment Planning Division and Pollution Control Division and were summarized in a report by Hamilton and Brassard (1983).

Data regarding the Highwood River was collected primarily by Alberta Environment Pollution Control Division and were summarized in Charlton and Brennan (in prep.).

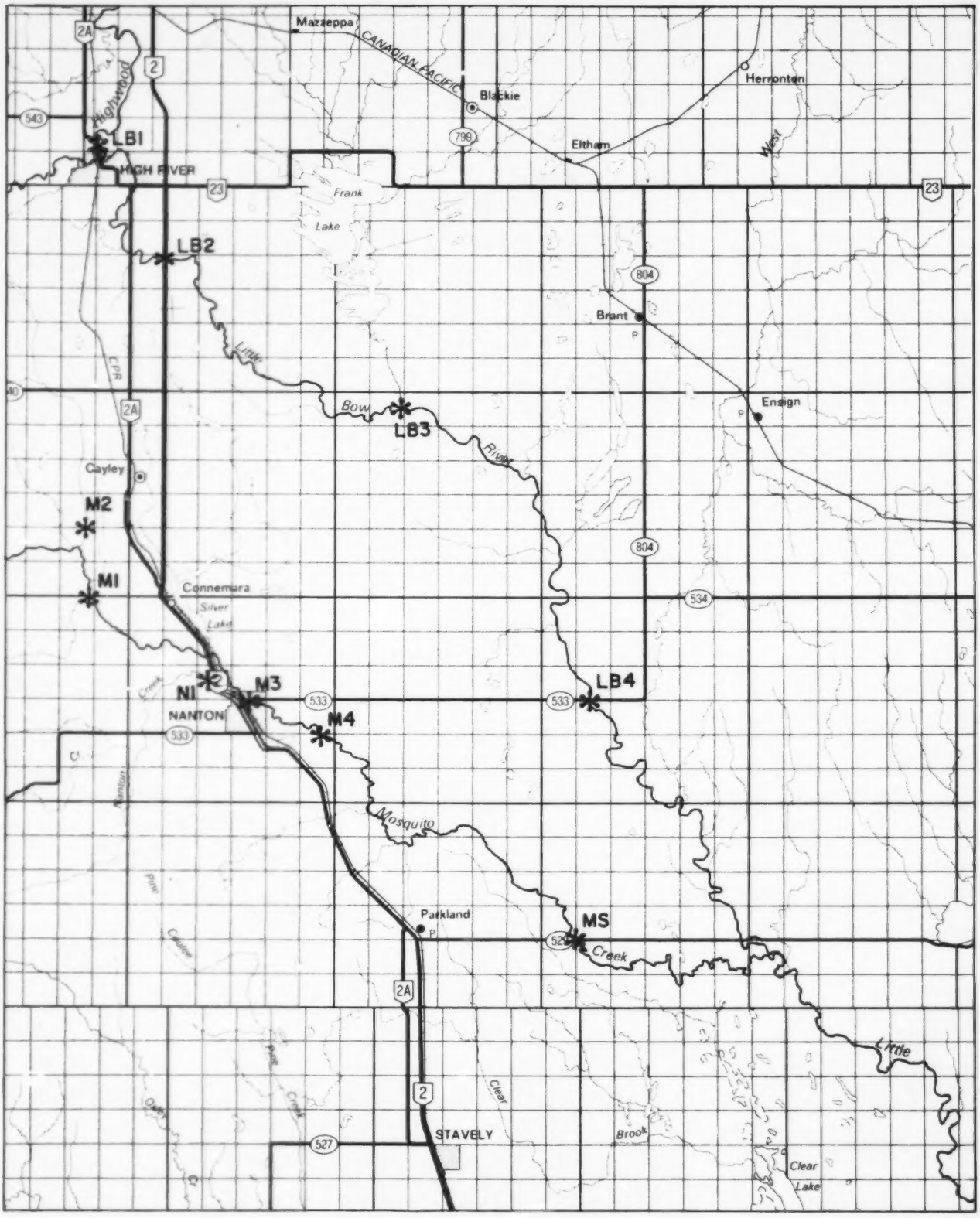
Data were also taken from a survey of 71 Southern Alberta reservoirs and lakes conducted by Alberta Environment Pollution Control Division and Planning Division (Charlton 1986).

Stations from the Alberta Naquadat files are listed in Table 4.1 and mapped in Figure 4.1.

*This section was prepared by J. Crosby of Alberta Environment, Planning Division.

Table 4.1 Water Quality Sampling Locations Used for Water Quality Data Analysis.

Name of River	Name of Station	Map Ref. No.	No. of Samples	Sampling Period
Little Bow River	Little Bow Canal at High River 00AL05AC1010	LB1	10	10 Feb. - 13 Oct. 1982
Little Bow River	Little Bow R. at Hwy. 2 Southeast of High River 00AL05AC1000	LB2	10	10 Feb.- 13 Oct. 1982
Little Bow River	Little Bow River South of Frank Lake 00AL05AC1020	LB3	10	10 Feb.- 13 Oct. 1982
Little Bow River	Little Bow River at Rd. #533 E. of Nanton 00AL05AC1040	LB4	10	10 Feb. - 13 Oct. 1982
Mosquito Creek	Tributary of Mosquito Creek S.E. of Cayley 00AL05AC1080	M2	9	26 Mar. - 13 Oct. 1982
Mosquito Creek	Mosquito Creek at Road #529 East of Parkland 00AL05AC2060	M5	9	26 Mar. - 13 Oct. 1982
Highwood River	Highwood River below Pekisko Creek 00AL05BL0100	HR1	26	24 Aug. 1983 - 10 Dec. 1985
Highwood River	Highwood River above Town of High River 00AL05BL0200	HR2	29	24 Aug. 1983 - 10 Dec. 1985
Highwood River	Highwood River above Highwood Sewage Treatment Plant 00AT05BL2000	HR3	24	31 Jan. - 5 Dec. 1978



WATER QUALITY
SAMPLING LOCATIONS
SCALE 1:250 000

Fig. 4.1

4.2 Existing Water Quality in Little Bow Basin

The water quality in the Little Bow Basin was examined by the Planning and Pollution Control Divisions of Alberta Environment in 1982 (Hamilton and Brassard 1983). Samples were taken from 12 sites on ten occasions from March to October and analyzed for 50 parameters.

When seasonal averages of each parameter were compared to the Alberta Surface Water Objectives (Appendix C), 14 were found to exceed the guidelines on at least one date. The most common non-compliant parameters were total phosphorus, phenols, iron and colour. Heavy metals and pesticide/herbicide residues are not a problem in the basin at present, with most below detection limits.

Under the current water regime, there is no limitation to use of water for irrigation or livestock consumption. Specific restrictions to the use of Little Bow River or Mosquito Creek water for domestic supply after adequate treatment are not apparent. Some restrictions exist for water contact recreational use.

Use of the basin for freshwater fish is limited, notably due to oxygen depletion in winter.

At present, up to 4.5 m^3/s can be diverted from the Highwood River into the Little Bow River. Therefore water quality in the Little Bow River basin is highest during July and August, when local run-off is low and most of the streamflow consists of good quality water diverted from the Highwood River. Poorer water quality conditions exist throughout the basin during winter and spring for most parameters.

Agricultural activities and natural sources related to surface run-off are the primary factors influencing water quality in the basin.

There are no industrial discharges to Mosquito Creek or Little Bow River and just one continuous municipal discharge from the town of Nanton into Mosquito Creek.

Macrophyte and algal growth is heavy in the basin due to high nutrient levels and favourable physical conditions.

In a recent livestock assessment of the Little Bow Drainage Basins, prepared by the Standards and Approvals Division of Alberta Environment (1982), a livestock water contamination index was developed. The index was based on four factors:

- proximity of main facility to watercourse;
- livestock pasture in watercourse;
- run-off potential of land; and
- livestock density.

The result of the contamination index rating revealed that 17 livestock operations out of 204 in the basin had a definite potential for water surface contamination. Of these, the following five may have direct impact on the four reservoir sites:

- one site upstream of site LB1 (just below the Little Bow Canal) on the Little Bow River;
- one site on a very small intermittent tributary to Squaw Coulee Site 2 (only of concern during periods of high run-off);
- one site above Sites 7B1 and 7A (a few kilometers below High River Hutterite Colony) on the Little Bow River; and
- two sites on Mosquito Creek just downstream of Nanton which could affect the downstream portions of Sites 7B1 and 7A.

No sites on the Highwood River upstream of diversion points were listed as having a high contamination potential.

4.3 Existing Water Quality in the Highwood River

The water quality of the Highwood River has recently been examined by Pollution Control Division of Alberta Environment (Charlton and Brennan, in prep.), with additional data on temperature, oxygen and flows from Planning Division of Alberta Environment (Brassard 1986).

Summaries of water quality data from two sites sampled in 1983-1985 and one site sampled in 1978 on the Highwood River near the points of diversion to the Little Bow River or Mosquito Creek are presented and discussed in Appendix C.

In general, the quality of the water in the Highwood River is excellent upstream of the town of High River (both diversion points are located upstream of any town effluents). Mean open water (April 1 to Oct 31) total phosphorus concentration is 0.011 mg/L* with an annual mean monthly maximum of 0.029 mg/L in May (Figure 4.2). Salinity is low with a mean of 340 umhos/cm (Figure 4.3).

Comparisons of the phosphorus concentration and specific conductance of the Highwood River with that of the Little Bow River and Mosquito Creek are shown in Figures 4.2 and 4.3.

4.4 Reservoir Site Selection Based on Water Quality

The water quality factors to consider when selecting a reservoir site include trophic status, oxygen concentrations, recreational optima, water quality impairment after initial flooding and the effect on downstream water quality.

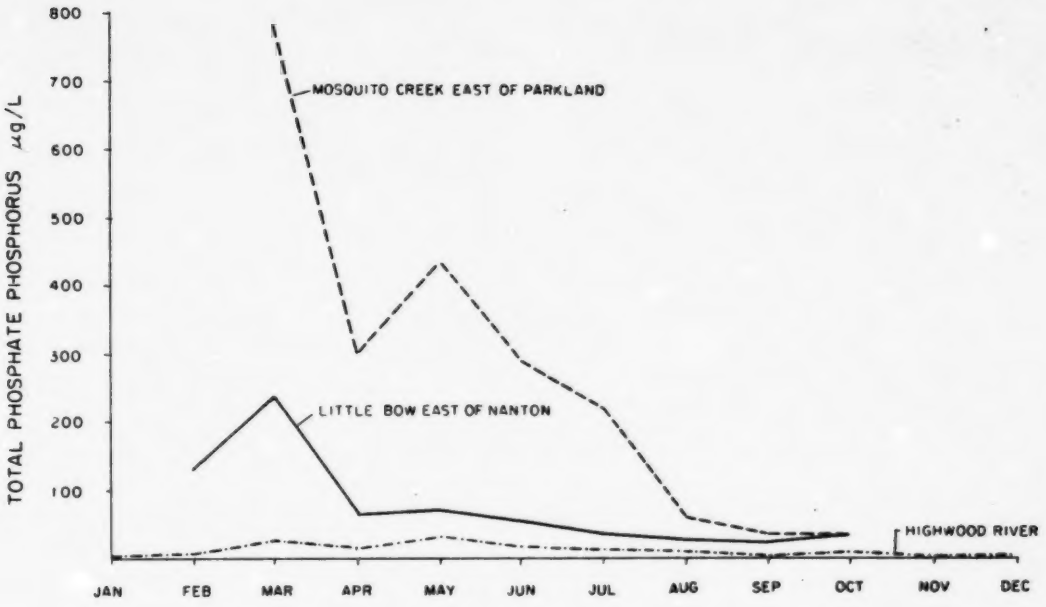
4.4.1 Trophic Status

The trophic state of a reservoir or lake is a measure of its biological productivity. Water bodies are commonly classifed into four trophic states:

Oligotrophic - low productivity, plant and algal growth minimal, water clear, oxygen concentration stable.

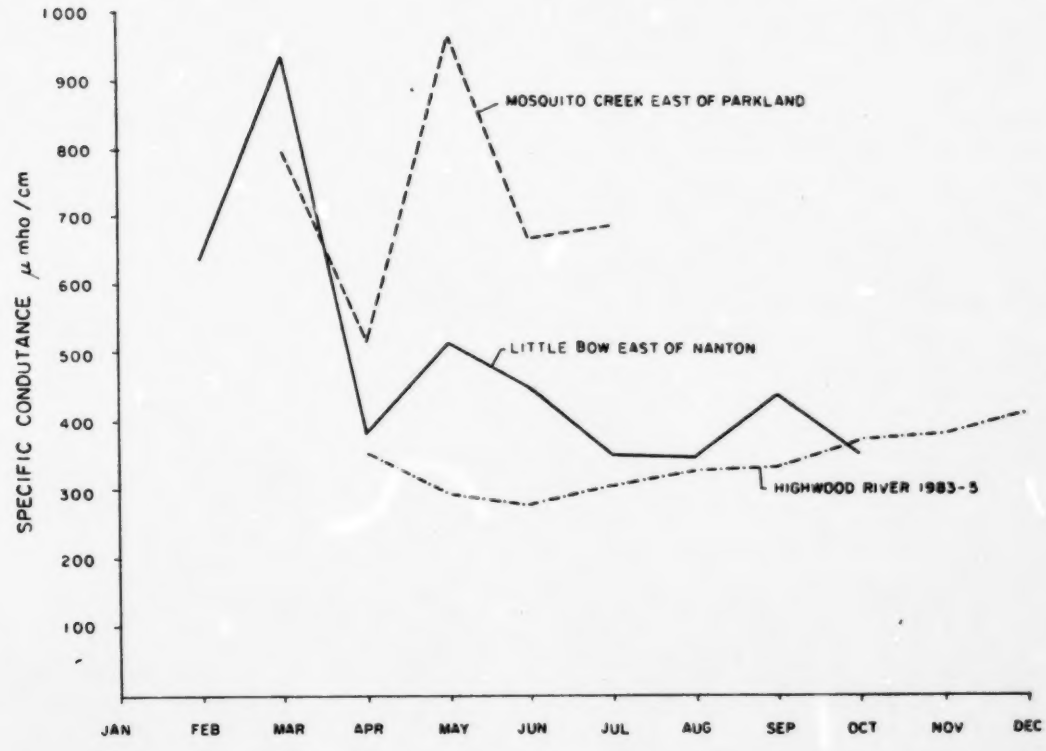
Mesotrophic - moderate productivity. Plant and algal growth present but only occasionally a nuisance. Oxygen reasonably stable.

* In the Naquadat station 00AL05BL0200 the July 26, 1984 value for total phosphate phosphorus of 1.25 mg/l was considered to be an eror and was deleted from the data set. There was no corresponding rise in other phosphorus or nitrogen values for this date. The total phosphorus value 8 days earlier was 0.006 mg/L; 4 days later it was 0.007 mg/L.



MEAN MONTHLY TOTAL PHOSPHORUS CONCENTRATION

Fig. 4.2



MEAN MONTHLY SPECIFIC CONDUCTANCE

Fig. 4.3

Eutrophic - High productivity, dense blue-green algae blooms, aquatic plants dense in shallow water. Oxygen concentrations fluctuate, fish kills can occur in both winter and summer.

Hypertrophic - Extreme productivity, very unstable oxygen concentrations, fish survival very poor, unstable chemical fluctuations.

Trophic state is dependant on a number of factors, with the most relevant ones in this case being nutrient loading, basin morphometry and flushing rates. In southern Alberta, low productivity reservoirs have low phosphorus content, fairly rapid flushing rates (at least once per year) and at least intermediate depth (mean depth greater than 4 m). Some reservoirs such as Travers, are unproductive even with a slower flushing rate, possibly due to its greater mean depth (14.5 m) (Table 4.2).

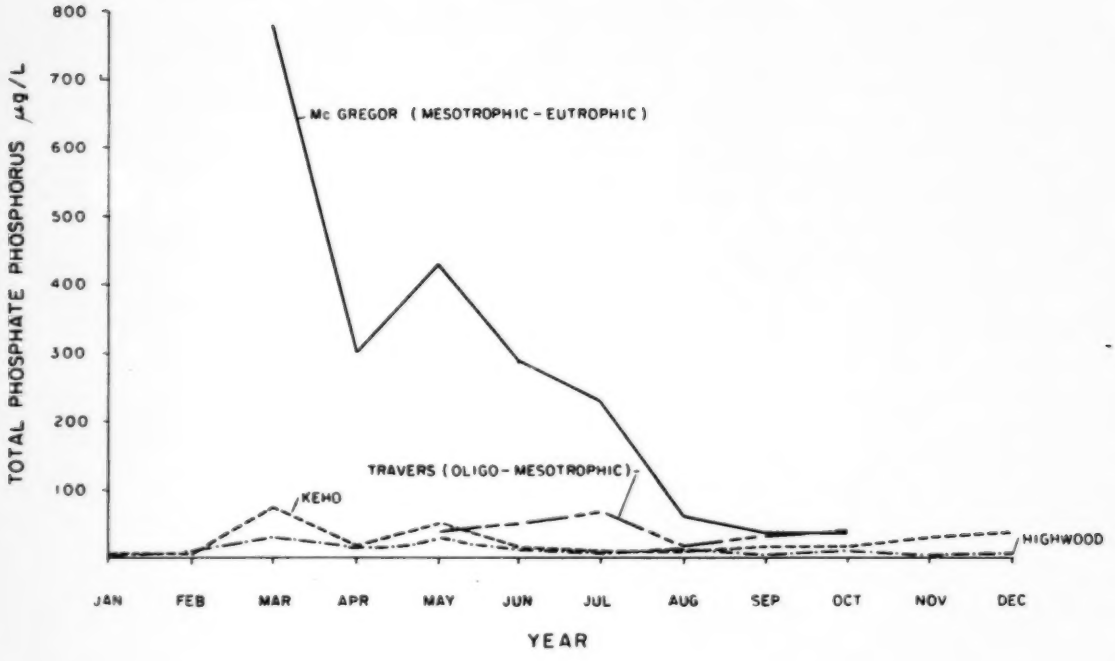
Phosphorus is generally accepted as the parameter most closely correlated with algal growth and trophic state. Figure 4.4 compares the phosphorus concentration of the main source of inflowing water for four existing reservoirs (McGregor, Travers, Little Bow and Keho) with that of the Highwood River near the points of diversion. Travers and Little Bow reservoirs are considered to be oligotrophic to mesotrophic, Keho reservoir mesotrophic to eutrophic, and McGregor is eutrophic (Charlton 1986). Based on the current phosphorus concentration of the inflowing water, a reservoir in the Little Bow Basin is predicted to be oligotrophic to mesotrophic. Downstream sites 7A and 7B1 will be slightly more productive due to additional phosphorus input from runoff and agricultural activity between the Highwood River and these sites.

Other factors must be considered when attempting to predict trophic state (Table 4.3). Nutrient release from sediments can occur under aerobic conditions (Mitchell 1984; Reynoldson and Hamilton 1982) but occurs to a greater degree under anaerobic conditions (Riley and Prepas 1984). All four reservoirs have sufficient depth that summer stratification could occur with subsequent anaerobic nutrient release. These nutrients could be trapped in the hypolimnion (at least temporarily) and then meet one of two fates:

Table 4.2
Chemical and Physical Characteristics of Some Southern Alberta Reservoirs
Data is largely Derived from Monitoring done in 1983–1984 (Charlton 1985).

	X TP mg/L	X CHL mg/m^3	Surface Area ha	X Depth m	Max Depth m	Volume dam^3	Flushing Rate 1/yr	X Turb JTU	X Cond us/cm	Probable Trophic State Based on TP	Probable Trophic State Based on Chlorphyll	Secchi m
Travers	0.015	2.3	2,307	14.5	39.6	334,560	0.7	2	369	O-M	O-M	3.91
McGregor	0.027	8.9	10,700	8.5	9.0	325,665	-	3	336	M-E	M-E	1.74
Little Bow	0.014	1.9	748	5.2	14.0	39.052	6.0	2	368	O-M	O-M	3.33
Chestermere	0.033	5.9	275	3.9	7.0	6,150	-	3	323	M-E	M-E	2.82
Newell	0.029	11.1	5,844	9.0	13.9	177,392	0	2	345	M-E	M-E	2.34
Little Fish	0.880	77.1	761	1.1	2.5	-	-	24	1734	H	H	0.42
Keho	0.040	2.7	1,861	0.7	3.2	-	-	13	310	M-E	O-M	0.82
Hanna	0.870	36.9	25	2.4	3.5	-	-	13	1139	H	H	0.45
Berry Ck.	0.750	77.3	567	1.7	3.0	-	-	5	830	H	H	1.28
Bld. Indian	0.370	10.4	107	2.5	3.5	-	-	4	2294	H	M-E	2.08
Eagle	0.388	-	-	2.7	-	31,130	-	15	1866	H	-	0.40
Clear	1.080	-	268	1.9	-	5,087	-	40	4972	H	-	0.21
Paine	0.025	-	244	3.7	-	8,908	-	1	209	M	-	2.50
Waterton	0.007	-	1,094	16.1	-	172,519	7.2	2	207	O	-	3.90
St. Mary	0.021	-	3,715	10.4	-	38,745	5.0	2	195	O-M	-	1.15
Chin (Stafford)	0.015	-	263	4.4	-	205,410	17.0	2	295	O-M	-	1.75
Chain Lk.	-	-	321	5.4	9.1	17,300	-	2	306	-	-	-

O = Oligotrophic
M = Mesotrophic
E = Eutrophic
H = Hypertrophic



MEAN MONTHLY PHOSPHORUS CONCENTRATION OF INFLOW WATER TO THREE RESERVOIRS AND THE HIGHWOOD RIVER

Fig. 4.4

Table 4.3
Morphometry and Estimated Flushing Rates of Four Potential Reservoir Sites in the Little Bow River Basin

	Mean Depth at F.S.L. (m)	Max. Depth at F.S.L. (m)	Flooded Area at F.S.L. (ha)	Volume at F.S.L. (dam^3)	Surface Area to Volume Ratio	Approximate Flushing Rate (per annum)
Site LB1	6.5	18.0	328	21,280	0.154	2.2
Site 2	7.3	21.0	243	17,760	0.137	1.9
Site 7B1	8.5	25.0	1,020	86,300	0.118	0.8
Site 7A	8.1	27.6	1,060	86,300	0.123	0.8

a) eventual mixing with the epilimnion and so stimulating algal growth, or
b) release downstream if the reservoir is built with bottom release facilities.

The net effect of stratification on the reservoir cannot be predicted until more details of construction and operation are known.

The higher surface area to volume ratio of sites LB1 and Site 2 may lead to higher amounts of atmospheric nutrient loading, greater potential for sediment nutrient release, higher temperatures due to solar heating and greater potential for wind action to mix the lakes than either site 7B1 or Site 7A. This will increase nutrient loading at these sites.

High flushing rates tend to reduce productivity (Placke Cox 1984). The slower flushing rates of the larger sites (7A and 7B1) should tend to increase their productivity over that in sites LB1 and 2. It should be noted that in all cases, most of the flow through the reservoir will be during the spring and early summer with little flow into the reservoirs from August until April. This results in an effectively faster flushing rate in the growing season than if the flow was constant through the year.

A quantitative estimate of the phosphorus concentration in each of the proposed reservoirs was made, based on the volumes of water expected to be diverted (Nanuk, pers. comm. monthly means of maximum diversion scenarios), phosphorus concentrations in the diverted water, natural mean volumes of flow in the basin (Nanuk pers. comm.) and the phosphorus concentration of that water. Atmospheric loading of total phosphorus to the reservoir was assumed to be 30.4 $g/m^2/yr$ (Trew 1978).

The mean phosphorus concentration in the reservoirs was predicted based on relationships developed by Jones and Bachmann (1976) where:

$$P = \frac{0.84\ L}{\bar{Z}(0.65 + \frac{1}{\bar{T}})}$$ * and by Vollenweider (1976)

where: $P = \frac{L/qs}{(1 + T)}$ *

* Where
- P = mean phosphorus concentration in the reservoir, mg/m^3
- L = annual areal load of phosphorus, mg/m^2
- Z = mean depth, m
- T = hydraulic detention time (yr)
- qs = areal hydraulic loading rate, $\frac{z}{T}$, m/yr

The results of these two methods found by Mueller (1982) for 68 North American reservoirs.

A prediction of chlorophyll concentrations (indicating algal production) was based on the relationship defined by Prepas and Trew (1983), using the phosphorus concentration predicted by Vollenweider (1976).

$$\log (CH1\ a) = -0.661 + 1.146 \log (P)$$

Wetzel (1983) proposed that chlorophyll and phosphorus concentrations were indicative of the following trophic states (Wetzel 1983):

	Chlorophyll a, mg/m^3		Phosphorus, mg/m^3	
	mean	range	mean	range
Oligotrophic	1.7	0.3-4.5	8	3-18
Mesotrophic	4.7	3-11	27	11-96
Eutrophic	14.3	3-78	84	16-386
Hypereutrophic	-	100-150	-	750-1200

The following assumptions were made to predict these values:

1) The volumes of water to be diverted from the Highwood and the natural volume of water in the basin were assumed to be accurately estimated by Nanuk Engineering.

2) All inputs were assumed to be evenly mixed in the reservoirs (this is likely not valid for site 7B1, comments regarding it follow).

3) Diversion through Squaw Coulee would be significantly increased over present if Site 2 were chosen but the Little Bow Diversion would continue to operate as well.

Results are shown in Table 4.3. At Site 7B1, Mosquito Creek enters the reservoir near the outlet from the reservoir. Since Mosquito Creek carries a fairly high nutrient load, the southern end of the reservoir may be more eutrophic, leading to algal blooms. If Site 7B1 is selected and if maintaining the reservoir for recreation use is a high priority, two recommendations to improve the water quality can be made:

1. Construct a bypass for Mosquito Creek so that nutrient-rich flow can be directly sent downstream when downstream water demand is high. Water can be diverted to the reservoir when filling the reservoir is a high priority.

2. Examine the possibility of alternate disposal for municipal sewage from Nanton and from feedlots on Mosquito Creek and the Little Bow upstream of the reservoir.

4.4.2 Oxygen Depletion

Summerkill of fish due to oxygen depletion is not expected to be a problem at any of the sites.

Table 4.4
Predicted Phosphorus and Chlorophyll a Concentrations in Proposed Reservoir Sites

Reservoir Site	L, mg/m^2	Z, m	area, m^2	T, yr	$\frac{1}{T}$, y^{-1}	Phosphorus con, mg/m^3		mean Chlorophyll a conc, mg/m^3
						Jones and Bachmann (1976)	Vollenweider (1976)	
2	156.3	7.3	2.4×10^6	0.52	1.9	7.06	8.67	2.6
LB1	171.7	6.5	3.3×10^6	0.45	2.2	7.78	7.12	2.8
7B1	176.2	8.5	10.2×10^6	1.25	0.8	12.01	12.2	3.8
7A	170.7	8.5	10.6×10^6	1.25	0.8	11.63	12.44	3.9

Winter oxygen depletion is common in shallow lakes and reservoirs in Alberta and if severe, can lead to winterkill of fish. The degree of oxygen depletion in winter is a function of mean depth of the water over winter, sediment surface area and productivity (i.e. amount of organic material in the reservoir at freeze-up) (Babin and Prepas 1985). If the reservoirs are close to fully supply in the late fall, winter oxygen depletion should not be a problem. However, if the reservoirs are significantly drawn down before freeze-up, winterkill could occur. Details of operation will need to be known to refine this prediction.

4.4.3 Recreational Water Quality

Recreational enjoyment of reservoirs is dependant on water clarity, plant and algal growth and bacterial concentration.

The upstream sites may have slightly less algal growth than the larger downstream sites 7A and 7B1. Rooted aquatic plant growth depends on the drawdown regime which is imprecisely known at this time. Water level manipulation is likely to be great enough in most years to keep rooted plant growth at a minimum at all sites.

Bacterial concentrations are likely to be low at the upstream sites and slightly higher at the downstream sites depending on livestock access immediately upstream. Local near shore problems could arise at all sites if livestock access is allowed or if livestock are concentrated on any areas directly draining to the reservoir.

4.4.4 Initial Conditions after Reservoir Filling

Reservoirs take several years before reaching stable state. For a few years after filling there is a "trophic" upsurge as nutrients in flooded topsoil and vegetation are released to the water, resulting in greater productivity than will be experienced later. Site LB1 and Site 2 may be affected more than sites 7B1 and 7A due to the greater surface to volume ratio at the upstream sites.

Mercury release from flooded soils and subsequent bioaccumulation in sportfish is a concern in new reservoirs (Bodaly et al 1984, Jones et al 1986). This may occur at all sites and monitoring of mercury levels should be planned.

4.4.5 Downstream Water Quality Effects

The existing diversions from the Highwood River to the Little Bow system already improve its water quality in the summer months and also to a small extent in the winter. The degree of dilution of nutrients such as phosphorus and salinity is presently limited by the availability of water in the Highwood during all but the spring runoff period. A reservoir on the Little Bow or Mosquito Creek would allow storage of good quality Highwood River water in the spring. Release of this through the later summer and winter would improve the water quality downstream throughout the year. A quantitative estimate of the extent of improvement cannot be made without further details on the volume of storage, irrigation demand and operating regime.

4.5 Summary

1. The present water quality in the Little Bow River is fair to poor with high specific conductance (salinity), high phosphorus concentration, and minor limitations for use.

2. The present water quality of the Highwood River is excellent at the proposed sites for increased diversion to the Little Bow River. Nutrients are of low concentration.

3. The proposed reservoirs are predicted to be oligotrophic to mesotrophic with slightly higher algal production expected at the two downstream sites. Site 7B1 could develop algal blooms at the south end due to inflow from Mosquito Creek. Two recommendations are made if recreational use of the reservoirs is a high priority.

i) An alternate bypass route to allow diversion of Mosquito Creek directly downstream.

ii) Consideration of alternate disposal of sewage and feedlot wastes.

4. Winterkill and summerkill of fish is not expected to be a problem at any of the reservoir sites except during periods of extreme drawdown.

5. Mercury concentrations may be elevated for a short period after flooding and should be monitored.

6. The water quality downstream of the reservoirs should improve significantly during periods of release from any of the proposed reservoirs.

4.6 Data Gaps

The primary requirement for a final water quality assessment will be detailed morphometric information on the selected reservoir and a confirmed operating regime for both the reservoir and the diversion canal. Additional reserach on potential point and non-point sources of contaminants, on the likely effects of increased flows on creek bed and channel stability, and some additional Highwood River water quality information would be advisable.

5.0 FISHERIES RESOURCE

The regional value of the Little Bow River fisheries resource above Travers Reservoir is low when compared to nearby drainage systems (IEC Beak 1983). This is due to the absence of salmonid spawning habitat and generally poor quality fish habitat (Wiebe 1978). Utilization of the river by recreational fishermen is considered to be low (L. Fitch pers. comm.). In the absence of diversion from the Highwood River system, fish habitat quality would decline even further. On the other hand, diversion and storage of additional Highwood River streamflows has considerable potential to increase fisheries habitat quality. If improperly planned, however, such improvements could occur at the expense of the existing and very valuable Highwood River fisheries resource (IEC Beak 1983). In general, fisheries gains (and losses) will also be a direct function of reservoir size, location, and operating regime.

The overview assessment of potential benefits/costs of reservoir development and increased Highwood River flow diversion on Little Bow River fisheries is based on general available literature, a basin overview prepared by IEC Beak (1983), and a subsequent fisheries assessment commissioned by Alberta Environment (EMA 1983). Discussions with Alberta Fish and Wildlife indicated that no new file data subsequent to those reviewed by IEC Beak (1983) were available. Although general reservoir impacts are briefly reviewed, primary emphasis is placed on a comparative analysis of the four reservoirs.

5.1 Existing Fisheries Resource

For purposes of analysis, the Little Bow River may be subdivided into three study reaches:

Reach 1 - Upper Little Bow River from Little Bow Diversion to Frank Lake confluence (Site LB1)

Reach 2 - Mosquito Creek from Squaw Coulee Diversion to Little Bow River confluence (Site 2)

Reach 3 - Lower Little Bow River from Frank Lake confluence to the wier at Carmangay (Sites 7B1, 7A).

5.1.1 Fish Species Composition and Distribution

Twenty species of fish representing 10 families are found within the Little Bow River basin in the study area (Table 5.1). Seven of these species are considered game fish by Alberta Fish and Wildlife, the remainder being classified as forage or coarse fish.

Game fish found within the upper reaches of the Little Bow River upstream of the Frank Lake outlet in the vicinity of Site LB1 (Reach 1) include mountain whitefish, brown trout, rainbow trout, and northern pike (Wiebe, 1978; IEC Beak, 1983; EMA, 1983). The first three species most likely originate from the Highwood River, as Wiebe (1978) found no suitable salmonid spawning habitat in the Little Bow River above Travers Reservoir. Wiebe (1978) and EMA (1983) state that this stream reach provides only marginal habitat for cold-water species such as trout and mountain whitefish. Northern pike, a warm water species, is generally found throughout this section of the river, as are several species of forage and coarse fish. Longnose dace and white sucker are numerically the dominant species present.

In the vicinity of Site 2, fish species reported in the Squaw Coulee diversion and Mosquito Creek (Reach 2) were northern pike, lake chub, fathead minnow, and white sucker (EMA, 1983). In the fall of 1982, the latter two species were the most abundant. Northern pike were only present in Mosquito Creek near the confluence with the Little Bow River. The low species diversity in this section of the study area is due to the poor habitat quality.

Fish species found in the area of Reach 3 near Site 7B1 and Site 7A include northern pike, lake chub, and white sucker (EMA, 1978). Northern pike was the most abundant species captured in the fall of 1982. Most pike captured were juvenile fish, indicating that this section of the stream is utilized as a rearing area and may also have some potential for spawning by pike.

Species diversity increases below the weir at Carmangay. Fish passage upstream past the weir is currently not possible. Therefore, fish movement (if any occurs) is only in a downstream direction.

Table 5.1 **Fish Species Found Within the Little Bow River Basin**

Scientific Name	Common Name
Salmo gairdneri	rainbow trout
Salmo trutta	brown trout
Coregonus clupeaformis	lake whitefish
Prosopium williamsoni	mountain whitefish
Esox lucius	northern pike
Perca flavescens	yellow perch
Stizostedion vitreum	walleye
Couesius plumbeus	lake chub
Pimephales promelas	fathead minnow
Rhinichthys cataractae	longnose dace
Semotilus margarita	pearl dace
Catostomus catostomus	longnose sucker
Catostomus commersoni	white sucker
Catostomus platyrhynchus	mountain sucker
Moxostoma macrolepidotum	northern redhorse sucker
Lota lota	burbot
Percopsis omiscomaycus	trout-perch
Culaea inconstans	brook stickleback
Cottus ricei	spoonhead sculpin

Source: IEC Beak Consultants Ltd., 1983
Environmental Management Associates, 1983

5.1.2 Existing Fish Habitat Capability

Fish habitat within the study area is generally of poor to fair quality. In Reach 1 (Site LB1), the substrate is mainly silt covered with aquatic macrophytes. Suitable northern pike and sucker habitat is found in this section of the river as well as lesser amounts of habitat for game fish species such as mountain whitefish and brown trout. The lack of instream and riparian cover, the poor substrate stability and suitability, and the extreme water temperatures occurring during the summer months are all limiting factors for most fish species, particularly salmonids, at this site (Wiebe, 1978; EMA, 1983). The shortage of suitable pool/riffle areas make this portion of the study area unsuitable as spawning and rearing habitat for most sport fish species. EMA (1983) report that northern pike spawning and rearing habitat is available in this area. Data collected during the winter of 1983 indicate that water depth and dissolved oxygen concentrations are suitable for overwintering in this reach of the Little Bow River (EMA, 1983).

Fish habitat in the vicinity of Site 2 is poor for spawning/rearing and overwintering fish. The substrate is generally silt with a few areas of gravel/cobble. The stream has been channelized through much of the area and little or no instream vegetation is present. Data collected during the fall of 1982 indicated that shallow water depth and low discharge limited the suitability of Squaw Coulee and Mosquito Creek as fish habitat (EMA 1983). Dissolved oxygen concentrations recorded during January 1983 were well below the recommended level of 5.0 mg/L, thus limiting the potential for overwintering fish.

Fish habitat near Site 7B1 and 7A (Reach 3) is generally fair to good for warm-water species. The substrate varies from areas that are predominantly silt to areas with gravel/cobble. Abundant aquatic macrophytes are associated with the silt substrate. This section of the river appears to provide good rearing habitat for northern pike (EMA, 1983). Potential spawning habitat for pike is also available. Several deep pools located within this section of the river would provide good overwintering fish habitat. Dissolved oxygen levels recorded in the middle reaches of the river during January 1983 (EMA, 1983) indicate that oxygen concentrations are sufficient to maintain overwintering fish. However, some sections of the river near this site have potentially critical oxygen concentrations for overwintering fish (Alberta Environment, 1983).

5.2 Impacts of Reservoir Development

Reservoir development may affect upstream and downstream riverine communities as well as aquatic communities within the impoundment. Upstream effects include blockage of migration and provision of overwintering habitat. Downstream effects include changes in aquatic habitat due to alterations in water quantity, temperature, and quality. Within the impoundment, major changes in primary productivity and aquatic invertebrate population structure may occur, along with dramatic shifts in fish species composition as habitat shifts from a lotic to a lentic environment. Reservoir preparation (i.e. degree of clearing) and operation (i.e. degree and timing of drawdown) may have very significant effects on reservoir ecology. In addition, mercury has been found to accumulate in fish to unacceptably high levels subsequent to impoundment in some cases (Wren et al, 1986). General reservoir effects common to all four potential Little Bow sites are discussed in Section 3.2.1, and site specific impacts are compared in Section 5.2.2.

5.2.1 General Effects

Upstream Effects

None of the four proposed reservoirs are expected to have significant negative effects on upstream fish population already within the Little Bow system. There is no evidence that the species currently using the stream are highly migratory or that unique habitat will be cut off due to the presence of the dams at any site. The reservoir presumably will improve overwintering potential for species adapted to lake environments (e.g. white suckers, lake whitefish) and so increase their abundance upstream of the reservoir.

A major negative impact may occur in the Highwood River system from offstream diversion during the late spring - early summer months. The high volumes of diverted waters can be expected to contain adult Bow River rainbow trout, which migrate up the Highwood River to spawn each year in late May. These fish are likely to bypass the diversion during the upstream migration provided adequate provisions are made for fish passage. During the downstream migration, however,

fish will be unable to distinguish the diversion flow from the main channel and will have a high probability of entering the Little Bow system. It is very likely that these fish will be lost permanently, since they are very unlikely to survive within either the Little Bow River or the reservoir. It is highly unlikely that adult losses can be prevented through the use of screens at the diversion since these would become clogged with run-off debris.

A similar situation likely exists for juvenile and young-of-year rainbow trout which also migrate downstream in the Highwood River during the early summer months. Once into the Little Bow River, they are also very unlikely to survive. Losses of both adult and juvenile rainbow trout from the Highwood River are likely already occurring. Increased diversions will increase this loss rate, particularly if diversions occur primarily during the late spring.

Within Impoundment Effects

Flooding of the Little Bow valley will result in inundation of large areas of soil and vegetation. Currently, no stripping of top soil is proposed (R. Middleton, Alta. Env. pers. comm. 1986). Inundation may lead to increased release of nutrients and a subsequent upsurge in primary productivity (Baxter and Claude 1980). Productivity may also be increased by large amounts of organic carbon becoming available directly from innundated vegetation (Hecky and Guilford 1984). On the other hand, high sediment loads in the Highwood River spring run-off, plus additional erosion from newly flooded shoreline may reduce light penetration and therefore reduce reservoir productivity. The net effect is expected to be a short term increase in productivity followed by a rapid decline. Drawdown in all reservoirs will also greatly reduce productivity. The magnitude of drawdown effects will be directly proportional to the degree of drawdown and to the relief in each reservoir. Drawdown is not anticipated to affect fish spawning success since the few fall spawning species (primarily lake whitefish) tend to spawn in relatively deep water. Drawdown will greatly reduce reservoir productivity due to freezing/dessication of the littoral zone, however it may be sufficient in some years to result in winter fish mortality due to low oxygen concentration.

Species composition in all four reservoirs is expected to be similar. Cold water game species (i.e. rainbow trout, brown trout, mountain whitefish) are considered highly unlikely to survive in any of the reservoirs. The most likely population composition of game species is northern pike, with much lower numbers of yellow perch and walleye. Lake whitefish will likely survive and reproduce, but will probably need to be stocked originally. Other species likely to become established are longnose suckers, white suckers, and burbot.

It is not possible to predict whether a successful recreational and/or commercial fishery will develop on any of the four reservoir sites. The success of the fishery will be primarily a result of the reservoir operating strategy. It is likely, however, considering the history of other, similar Albertan reservoirs, that at least a recreational pike and lake whitefish fishery will become established.

Use of the fishery that does develop within the new reservoir may also be limited by increases in mercury in fish tissue. The inundation of nutrient rich sediments interferes with normal soil/atmospheric mercury cycling processes. The result is creation of an environment which encourages the formation of organic mercury (methylmercury) by bacterial action. Methylated mercury is rapidly taken up by aquatic organisms, and through bioconcentration (in which concentrations of a substance within organisms are greater than those in the surrounding environment) and biomagnification (in which increased concentration of a substance occurs at increasing trophic levels in the food chain), mercury levels may reach unacceptable levels in fish, particularly top predators such as pike. There is some evidence that these elevated mercury levels decline with time, but the rate is variable. It is also not currently possible to predict the actual increase in methylmercury that would occur due to reservoir construction.

Downstream Effects

Few, if any, negative downstream effects are predicted for any of the reservoirs. Current Little Bow River flows are primarily artificially increased by diversion from the Highwood River and reduced through irrigation withdrawals. Presumably downstream flows will in fact be stabilized and possibly increased by the presence of on-stream storage of spring run-off. This will have direct positive benefits to

downstream fish populations. The withdrawal of hypolimnetic water (i.e. water from the bottom of the reservoir) below the dam will decrease summer temperatures. Providing the water is oxygenated, this will also be beneficial for downstream fisheries. Monitoring of downstream water quality may be required to ensure that water released from the hypolimnion is not harmful to fish.

One negative impact of storage of flood peaks is potential loss of pike spawning habitat. Pike spawn in heavily vegetated river floodplains (Scott and Crossman, 1973) in water depths generally less than 0.5 m. If flood control is effective, natural inundation of spawning habitat may be reduced or eliminated.

5.2.2 Site Specific Effects

Site LB1

Under the present flow regime, Site LB1 provides only marginal habitat for both game fish and coarse/forage fish. Construction of a reservoir at this site would result in the loss of some pike rearing habitat. Other sport fish species such as mountain whitefish and rainbow trout are generally limited to the headwaters of the Little Bow River at the diversion canal from the Highwood River and are not present at this site in significant numbers. It is expected that locating a reservoir at Site LB1 would have negligible impacts on these species.

Under the present flow regime, some suitable fish habitat currently exists downstream of Site LB1 which would be vulnerable to changes in flow. In particular, pike spawning habitat could be affected. Flow regimes that reduce spring runoff may also reduce available spawning habitat in this area. If this type of habitat is available under the existing flow regime and is utilized by spawning northern pike, maintaining some natural peak flows during the spring under a flow regulation scenario should not adversely affect this species. At present, dissolved oxygen levels are usually sufficient to sustain overwintering fish. Assuming that natural flow during the winter months will at least be maintained, no effects on overwintering fish are anticipated.

Drawdown in reservoir Site LB1 (Table 1.2) will be extensive due to its relatively small size and heavy irrigation pressures. Alberta Fish and Wildlife estimate that a minimum depth to prevent winter kill is 3 m (10'). Although no morphometry data are available for Site LB1, it appears that winter kill in the reservoir could be expected 1 year out of 20 during the first years of operation and 1 year out of 5 after ten years. It is not possible to predict the degree of littoral exposure during the expected late summer fall and winter drawdown period.

Site 2

At present, fish habitat at Site 2 is of poor quality. Construction of a reservoir at this site would have no significant adverse effect on existing fish habitat. Under the existing flow regime, no suitable downstream habitat for important fish species has been identified. Sub-optimal dissolved oxygen concentrations during the winter months make this area unsuitable for overwintering fish. By increasing flows during the winter, the potential for increasing the overwintering capability for fish may be enhanced.

As at Site LB1, drawdown at Site 2 would be extensive. Its slightly greater maximum depth may make it slightly less vulnerable to winter kill. In the absence of basin morphometry information, it is not possible to estimate effects of drawdown at Site 2 on littoral zone development.

Site 7B1

At present, Site 7B1 provides fair to good habitat for warm-water fish species. Reservoir construction would result in the loss of rearing habitat and possibly spawning habitat, primarily for pike. Fish habitat downstream of the reservoir is also rated as fair to good. Flow augmentation from the reservoir would likely be beneficial to fish habitat at this site. Spawning areas for lake whitefish originating from Travers Reservoir have been identified downstream of the weir at Carmangay. With a decrease in flows, spawning habitat for this fall-spawning species may be reduced or lost; fall and winter flow incrases would be beneficial. At present, lake whitefish provide an important recreational and commercial fishery in Travers Reservoir. Augmenting flows would ensure retention of

spawning areas and the overwinter survival of embryos; flow enhancement in the winter may have positive impacts on whitefish egg survival.

Winter dissolved oxygen levels in the Little Bow River are currently sufficient to sustain overwintering fish. Dissolved oxygen levels in Mosquito Creek, however, may drop below acceptable levels in winter due to lower overall discharge volumes.

The substantially larger size of the reservoir at Site 7B1 will reduce the risk of winter kill arising from significant drawdown. A review of the reservoir morphometry indicates that with a 5' drawdown, the upstream 20% of the reservoir (approximately) will be drawn down to the original stream valley. The remainder of the reservoir is relatively "insensitive" to drawdowns up to 20' due to the relatively steep shoreline. Larger drawdowns (30-40'), which are predicted on the basis of Alberta Environment data to occur 3 or 4 years out of 10 during the first 20 years of operation will result in the exposure of almost 65% of the reservoir. Such drawdown will greatly reduce reservoir productivity.

Site 7A

The fisheries resource at Site 7A is similar to that described for Site 7B1 due to the large overlapping area and similar size of the two sites. Construction of a reservoir at this site will result in the probable loss of rearing and spawning habitat for nothern pike, but this habitat will be replaced within the reservoir. A reduction in flows from the natural condition downstream of the reservoir would also be expected to result in the loss of pike spawning and rearing habitat; flow augmentation would improve downstream habitat quality. Drawdown effects at 7A will be similar to those at 7B1. The amount of exposed shoreline with a 5' drawdown may be somewhat greater, however, in reservoir 7A, and a 10' drawdown will result in approximately one third of the reservoir having depths of less than 0.5 m. Again, significant reductions in reservoir productivity can be anticipated if large drawdowns occur.

5.3 Summary

Flows, and therefore fisheries, within the Little Bow River are currently artificially controlled by diversion and irrigation demand. The existing aquatic habitat is generally of low quality. As a result, reservoir construction has some potential to imrpove current recreational and possibly even commercial fishing opportunities. If fall and winter downstream flow augmentation is possible, positive impacts will be even greater.

At present, fish habitat within the study area is marginal. In general, factors limiting fish distribution in the Little Bow River are lack of suitable substrate, lack of instream and riparian cover, and sub-optimal winter dissolved oxygen concentrations.

Of the four sites, development of a reservoir at Site 2 would result in the smallest lost of stream habitat, plus the greatest potential for positive benefits from downstream flow augmentation. Productivity would likely be greater in either 7B1 or 7A due to their larger size, and both are probably less vulnerable to winter kill than the two smaller reservoirs. Presumably, the larger reservoirs would be able to provide steadier fall and winter downstream flows. All four reservoirs appear likely to experience significant drawdown causing unknown, but probably serious reductions in productivity.

Negative impacts from reservoir development will likely include loss of adult, juvenile, and fry rainbow trout from the Bow River system, and high mercury concentration in the tissue of resident sport fish. No methods of mitigating these impacts are evident.

5.4 Data Gaps

The fisheries study is based on general overview data and on minimal site-specific data. No angler data were available. Given the poor nature of the fishery in the upper Little Bow River basin, it is doubtful that extensive studies are warranted. It would, however, be worthwhile to conduct a spring fisheries and habitat assessment survey to determine if northern pike utilize the study area for spawning, particularly at Sites LB1 and 7B1.

A brief assessment of the potential positive impacts of downstream flow augmentation would also be warranted. If improvements in current downstream conditions are significant, a benefit/cost analysis of providing fish passage at the Carmangay weir would be recommended.

6.0 WILDLIFE RESOURCE

Wildlife information for the four potential reservoir sites was obtained primarily from existing literature sources, personal communications with government officials and local residents, and interpretation of 1:10,000 scale air photos. Field notes on wildlife and wildlife habitat were recorded during the two-day land use field assessment conducted on October 31 and November 1, 1985.

It should be noted that very little documented information is available concerning the wildlife resource of the reservoir sites or the surrounding region. Provincial government officials in Edmonton, Calgary, and Lethbridge were contacted to determine existing literature sources. Apart from key Wildlife Area Maps prepared by Alberta Fish and Wildlife Division and the Canada Land Inventory Maps there is no information on wildlife habitat and only one report (prepared by Environmental Management Associates in 1983) on wildlife population and distribution. The Alberta Fish and Wildlife Division has done some aerial surveys in the Travers Reservoir area but none in the immediate vicinity of the four reservoir sites (Lorne Russell, pers. comm.). Thus, the primary source of wildlife information for this report was personal communications with knowledgeable government officials and local residents.

6.1 Existing Wildlife Resource

Due to intensive agricultural practices there is only a small amount of wildlife habitat present at each of the four reservoir sites. For this reason, the available habitat is considered critical in a regional context. Schmidt (1981) and Hart et.al. (1981) define critical habitat as:

> "the **best existing habitat** in the region for the major wildlife species under consideration. Critical habitat also ranks as good or better in a provincial context. Critical areas support significantly higher populations than any other in the map area on a seasonal or year-round basis. Consequently, the loss of a unit of critical habitat and the associated loss of identified populations would have significant regional, and possibly provincial implications".

At each of the four reservoir sites, wildlife habitat is synonymous with "native land" as identified in Section 3.0, Land Use. Wherever there is a small stand of trees, shrubs, or shoreline vegetation that has not been cleared or disturbed for some agricultural purpose, there is use of that area by wildlife for food and cover. Intensive use was inferred during the field inspection not only from signs of browsing but also from the consistency of wildlife sightings at each of the vegetated areas. These observations serve to emphasize the regional significance of these critical habitat areas.

Limiting factors affecting wildlife habitat capability at the four sites are as follows:

- lack of forest and shrub communities, due to semi-arid conditions occurring regionally;
- scarcity and distribution of open water;
- very steep terrain in a number of areas of prime native land; and
- intensive agricultural use.

Intensive agricultural land use is the most important limiting factor listed above since it results in:

- decreased forage availability due to grazing and cultivation;
- decreased cover due to clearing; and
- harrassment of wildlife due to human activity (IEC Beak, 1983).

Forty-one mammalian species are reported to occur in the area of the reservoir sites (Soper 1964, Banfield 1974); however, 23 of these species are considered rare either because suitable habitat for the species is not common or because they are at the limits of their ranges. None of the 41 species are endangered (Novakowski 1970) and none are unique to any of the four reservoir sites.

The land around the four sites has moderately severe limitations to the production of ungulates (CLI Class 5). The limitations associated with this rating include high aridity, adverse topography, and poor soil fertility (Walsh and Walton, 1972). Mule deer (Odocoileus hemionus) and white-tailed deer (O. virginianus) are the only ungulate species that inhabit the reservoir sites. Eleven carnivore species are expected to occur in the area (Soper 1964, Banfield 1974). Other mammals expected to occur include two species of shrews, seven species of bats, three lagomorphs, and fourteen species of rodents.

Over 180 species of birds are expected to occur in the area as residents, migrants, or "accidental occurrences"; however, habitat for many of these species is severely restricted at the reservoir sites. Major limiting factors include:

- lack of nest sites for above-ground nesters;
- lack of escape cover; and
- lack of foraging habitat for species which forage in forest cover (IEC Beak 1983).

Four endangered species of raptors may occur at the reservoir sites (Godfrey, 1970), including the bald eagle (Haliaeetus leucocephalus), the osprey (Pandion haliaetus), the prairie falcon (Falco mexicanus), and the Peregrine falcon (Falco peregrinus). The status of these species of each of the sites is unknown.

Mitchell (1959) considered the region in and around the reservoir sites to provide some of the best habitat in southern Alberta for upland game birds. Recently, however, Braden (pers. comm.) indicated that habitat quality for all upland game birds is poor, primarily due to a lack of cover. This apparent decrease in upland game bird habitat quality is probably due to the level and intensity of agricultural activity in the area. Natural ring-necked pheasant (Phasianus colchicus) populations in the basin are augmented by birds raised in captivity and released by Alberta Fish and Wildlife as well as other organizations, groups, and individuals.

There are moderately severe to severe (CLI Class 5 and 6) limitations to the production of waterfowl at the reservoir sites primarily due to reduced marsh edge along the river banks, adverse topography, and a poor interspersion of

wetland and upland habitats (Schick, 1971). The reservoir sites are located along the "central flyway", which is an important migration route for many game duck species (Kartright, 1967).

Four species of reptiles and four species of amphibians are expected to occur at the four sites (Soper 1964, Banfield 1974). None of these species are considered rare or endangered.

No key wildlife areas have been mapped by Alberta Fish and Wildlife Division on the wildlife Key Area Map (updated, 1981) for any of the reservoir sites.

Site-specific wildlife information for the four reservoir sites is grouped into five categories: Ungulates, Furbearers, Waterfowl, Upland Game Birds, and Raptors. The first four categories were selected because of the economic importance of each species group and the latter due to the rarity of some of the member species and their sensitivity to environmental change. These wildlife categories are discussed for each reservoir site in the following sections.

6.1.1 Site LB1

Site LB1 has more wildlife habitat relative to its total area than any of the other reservoir sites. Stream and upland vegetated areas comprise 21% and 9% of the surface area of this site, respectively. Excluding the thin belt of riparian habitat adjacent to the Little Bow River, the primary areas of wildlife habitat are located on the steep, north facing slopes where no agricultural land development is possible. Two major vegetation belts are present within the boundaries of the site, one in the western half of the site near the road which traverses the river valley and the other in the eastern portion of the site immediately downstream of the small tributary that enters the Little Bow River. The western band of habitat is comprised primarily of wolf willow (Elaeagnus commutata) and snowberry (Symphoricarpos albus). No aspen (Populus tremuloides) is present. The understory species include numerous berry plants such as saskatoon (Amelanchier alnifolia), chokecherry (Prunus virginiana), and buffalo berry (Shepherdia canadensis), as well as rose (Rosa spp.). The eastern (and larger) band of habitat contains all of the plant species listed above, in addition to some small stands of

aspen. This site represents one of the best berry-picking areas in all of the Little Bow River Basin (Brian Jones, pers. comm.).

The two major bands of wildlife habitat as well as a few other small stands of vegetation provide suitable habitat for mule deer and, to a lesser degree, white-tailed deer. Mule deer sightings were made during the field reconnaissance and an inspection of the willow species revealed a considerable amount of browsing. Local residents report that, despite habitat availability, there are a greater number of white-tailed deer than mule deer (Akitt, Jones, pers. comm.). Although no sightings of economically important furbearers were made by BEAK staff during the field reconnaisance, landowners report that a population of at least twenty coyotes (Canis latrans) utilize the river valley at Site LB1 (Jones, pers. comm.). Environmental Management Associates (1983) reported sightings of ten mule deer and two coyotes on two separate aerial surveys along the river valley. Red fox have been observed in the upland areas (Akitt, pers. comm.) and there are a substantial number of porcupines and badgers (Jones, pers. comm.). Beaver are found all along the Little Bow River and are generally considered a nuisance, since they tear down the Saskatoon bushes and sapling aspen which provide cover for other wildlife species (Akitt, pers. comm.). Signs of muskrat (Ondatra zibethicus) were evident in the Little Bow River and it is assumed that American mink (Mustela vison), which prey upon muskrats, would also be present. Suitable habitat is present to support white-tailed jackrabbit (Lepus townsendii) as well.

Waterfowl production is moderately high at Site LB1 as compared with other river valley sites in southern Alberta (George Freeman, pers. comm). There is good nesting cover along the banks of the Little Bow River and nesting success is high. One or two pairs of Great Blue Herons nest in the river valley each year. Suitable habitat forupland game birds exists; however, the small amount of cover is the primary limiting factor. Hungarian partridge (Perdix perdix) and ring-necked pheasants were observed during the field observations. The ring-necked pheasants had been recently released as part of a raise-and-release program by Alberta Fish and Wildlife. A substantial population of native pheasants are said to exist in the valley at Site LB1 (Jones, pers. comm.). The native pheasants are distinguished by a lack of the nose markings that are present on all captive raised pheasants as a result of eye blinders, which are used to reduce aggression among the birds under

crowded conditions. No captive pheasants were released in the vicinity of Site LB1 by Alberta Fish and Wildlife in 1985 (Lyle Lester, pers. comm.).

Only minimal information is available for raptors in the general region of the four proposed reservoir sites. Locals report the presence of raptor nests on the north facing slopes (Akitt, pers. comm.). The primary factors affecting raptor productivity due to reservoir construction are:

- loss of nesting sites and
- loss of small mammal prey.

Flooding of areas with steep terrain that are good for nesting as well as sites with a large extent of pasture land, which is preferred by small burrowing rodents, would have the greatest impact on raptors (A. Wisely, pers. comm.).

6.1.2 Site 2

Site 2 is virtually devoid of any wildlife habitat. There are only two small stands of willow (with a saskatoon/chokecherry understory) towards the southern end of the study area comprising only 1% (2 hectares) of the surface area of this site. There is some riparian habitat adjacent to the streams in the southern half of the site but in the northern portion even this shoreline vegetation is absent due to stream channelization downstream from the Squaw Coulee dam.

There is virtually no habitat for ungulates at Site 2. The two stands of willow would only be sufficient to provide cover for a maximum of one mule deer. Both sites show evidence of being heavily browsed. Concerning furbearers, coyotes may use the coulee as a travel corridor, but there is no cover within the river valley. Because of the low flows in the stream bed it is unlikely that muskrat and/or beaver utilize this area. No evidence of either of these rodents was observed during the field inspection.

Waterfowl production at this site would be significantly lower than the other three sites due to the comparative lack of shoreline vegetation. Furthermore, this site is west of the two other sites and therefore only on the fringe of the central

migratory flyway. There is a reduction in waterfowl species diversity as one nears the mountains simply due to overall habitat changes (i.e., there are significantly fewer diving ducks) (George Freeman, pers. comm). Upland game birds and raptors are also not as prevalent at this site due to a lack of any vegetative cover and because Site 2 lies more on the fringe of the true prairie habitat which these species prefer. Approximately 120 captive-raised pheasants were released in the vicinity of Site 2 in 1985 by Alberta Fish and Wildlife officials (Lyle Lester, pers. comm.). Ferruginous hawks (Buteo regalis), which nest on steep coulee banks, and Prairie falcons (Falco mexicanus), which prefer steep cliffs as nesting habitat, are the most important raptors in the vicinity of this site (Brian Shantz, pers. comm.). It is unlikely that there are any raptor nests within the boundaries of Site 2 because of an almost complete absence of nesting sites.

6.1.3 Site 7B1

Site 7B1 has a large amount of wildlife habitat (second only to Site 7A); however, a large portion of this is contained in a thin band of riparian vegetation along the Little Bow River and Mosquito Creek. Nonetheless, there are a number of upland wildlife habitat sites interspersed throughout the river valley, the largest of which is located on Mosquito Creek upstream of the Little Bow River. At this site there are numerous shrubs all along the banks and in the river valley itself. Also, there are many bluffs and hummocks along the banks which provide cover for a wide variety of wildlife species. These upland vegetated areas comprise 4% (41 hectares) of the surface area of Site 7B1. Vegetation species occurring within this area include willow, birch (Betula spp.), and aspen in the overstory and Saskatoon, snowberry, chokecherry, rose, rough fescue (Festuca scabrella), and Parry oat grass (Danthonia parryi) in the understory. Marginal to adequate ungulate habitat is present at approximately four locations within the boundaries of Site 7B1.

Most wildlife habitat areas consist primarily of low shrubs and berry bushes with moderate food and cover value. Very good ungulate habitat exists at the aforementioned area on Mosquito Creek. More than 10 mule deer were observed at this location during the field reconnaissance. Landowners report whitetailed deer populations, upwards of 30 in number, travelling up and down the river valley throughout the year (Lievaart, pers. comm.). Bob Monkman, a local landowner and

hunter (pers. comm.), was of the opinion that there are relatively few deer in the river valley as compared with previous years. He felt that mule deer would be more affected by a reservoir than white-tailed deer, since mule deer spend more of their time in the river valley than on the upland areas. Good habitat exists for coyotes at this site (two coyotes were observed along the top of the bank during the field reconnaissance). Seven coyotes were sighted by Environmental Management Associates on two separate aerial surveys conducted along the river valley in 1983. Approximately twenty coyotes are thought to live in the river valley (Lievaart, pers. comm.). Coyote populations are thought to be on the increase (Monkman, pers. comm.). Muskrat habitat exists along the Little Bow River and Mosquito Creek at Site 7B1, as evidenced by field observations. Beaver dams were also noted along Mosquito Creek. Beavers are not favored by local residents since they are quickly depleting the last remaining stands of aspen in the river vally (Andrews, pers. comm.). Badgers are reported to be found throughout Site 7B1 (Lievaart, Monkman, pers. comm.).

Waterfowl production is better than average compared with surrounding streams due to the riparian vegetation, which provides nesting cover (George Freeman, pers. comm.). It is estimated that this site is slightly more productive than Site LB1 simply because of increased flows and longer shoreline length at this site. Approximately 40 whistling swans (Olor columbianus) were observed on the Little Bow River during the field reconnaissance, possibly indicating the presence of an important staging area. Indeed, local landowners Hans and Judy Lievaart report that 40-50 swans stop over at this site for approximately two months every spring and fall. Site 7B1 provides good habitat for upland game birds. Approximately 40 ring-necked pheasants and 10 Hungarian partridge were observed during the field reconnaissance. Approximately 1100 ring-necked pheasants were released by Alberta Fish and Wildlife officials at five locations within the vicinity of 7B1 in 1985 (Lyle Lester, pers. comm.). Local residents report that there is high winter mortality since these birds are not adapted to the wild (Lievaart, Williams, pers. comm.). Shorebirds observed by landowners at Site 7B1 include great blue heron (Ardea herodias), black-crowned night herons (Nycticorax nycticorax), american avocets (Recurvirostra americana), common snipes (Capella gallinago), curlews (Numenius spp.), and sandpipers (Erolia spp.) (Lievaart, Whiteside, Andrews, pers. comm.). A great blue heron colony has been identified by Alberta Fish and

Wildlife on the Little Bow river just upstream of site 7B1 (T116 R26 S20 W5).

It is anticipated that the productivity of raptors is moderately high at Site 7B1 due to the abundance of prey species in the area. Raptors reported to have been seen by landowners in the upper portion of Site 7B1 include red-tailed hawks (Buteo jamaicensis), rough-legged hawks (Buteo lagopus), golden eagles (Aquila chrysaetos), great horned owls (Bubo virginianus), pygmy owls (Glaucidium gnoma), and great gray owls (Strix nebulosa). Active nest sites for the golden eagles and great horned owls have been observed at this reservoir site (Lievaart, pers. comm.). A number of raptors were noted during the field inspection.

6.1.4 Site 7A

Site 7A has the largest areal extent of wildlife habitat of all four sites, both along the stream banks (201 hectares, 19% of surface area) and in the upland areas (64 hectares, 6% of surface area). A reservoir at the location would not, however, affect the primary wildlife site on the upstream portion of Mosquito Creek. Several areas of low lying shrub and berry bushes with the potential to support moderate numbers of upland game birds exist downstream of the 7B1 dam site. The primary wildlife habitat area in the southern portion of Site 7A occurs on the steep, north facing slopes in the widened river valley area just upstream of the 7A dam site. This area of steep terrain is densely vegetated with willow, buck brush, and berry bushes, and there are a number of sheltered bluffs and hummocks towards the base of the slopes. Adequate habitat for deer, coyotes, and upland game birds exists at this location. Landowners in the southern portion of Site 7A report the presence of 20-30 deer (mostly white-tailed deer) in the area. They also report an increase in raptor populations and a decrease in waterfowl and Canada goose populations (Fath, McDougall, pers. comm.).

6.2 Relative Impacts of Flooding

In attempting to determine which site has the most value for wildlife, the amount of vegetative cover appears to be the primary determining factor. Since different wildlife species groups utilize different wildlife habitats and since it is difficult to rate one wildlife species group as being more valuable than another, it was decided that all native lands in each of the three reservoir sites should receive equal weighting. In this manner, the reservoir with the largest area of native land will be determined to have the greatest value from a wildlife standpoint.

Site 7A has the largest area of native land and, therefore, would probably cause the greatest wildlife impacts due to flooding. Site 7B1 has a similar but somewhat smaller areal extent of native land and thus would have a slightly lower flood impact rating. Site LB1 would have intermediate wildlife impacts; however, this site would have the greatest impacts relative to its size. Site 2, which has only a very limited amount of native land, would have the least impacts due to flooding.

The presence of rare or unique wildlife species and/or habitat features and the potential for wildlife habitat enhancement were also taken into consideration in determining the wildlife value of the three sites; however, it was felt that the presence of rare or unique species (primarily raptors) was quite similar for the four sites and that the potential for habitat enhancement was in proportion to the existing habitat at each site.

It is relevant to note that approximately three-quarters of the native land occurring at the three sites on the Little Bow River and over 90% of the native land at Site 2 occurs along the stream banks. After flooding, it is possible that new shoreline habitat will develop along the banks at the new water line; however, Lorne Fitch of Alberta Fish and Wildlife (pers. comm.) is of the opinion that this new shoreline vegetation does not generally provide good wildlife habitat due to drawdown and overall fluctuating water levels. Depending on the magnitude and frequency of reservoir level fluctuations, it is possible that new shoreline vegetation might not develop at all.

Additional impacts of flooding on wildlife that could occur at all four sites are described below for each wildlife group.

Ungulates

- direct loss of food source as well as cover; and
- reservoir causes a physical barrier for upstream and downstream migrations along the river valley corridor.

Furbearers

- increased habitat for semi-aquatic furbearers in the shallower segments of the reservoir;
- the reservoir may cause a physical barrier to downstream and upstream migration to some semi-aquatic furbearers;
- direct loss of habitat to many small, burrowing furbearers in the valley bottom;
- direct loss of cover to large furbearers, such as coyotes; and
- loss of food source for carnivorous furbearers with loss of small mammals and upland game bird habitat.

Waterfowl

- decrease in breeding due to a reduction in the quality of nesting cover;
- increase in use of the area for staging;
- increase in overall waterfowl habitat in the shallower, upstream portion of the reservoir.

Upland Game Birds

- direct loss of source of food and cover.

Raptors

- Indirect loss of food source with loss of small mammal habitat; and
- direct loss of nesting cover.

In general terms, the flooding of any one of the four sites will likely cause all of the terrestrial wildlife currently utilizing the area to disperse into other areas. Waterfowl and semi-aquatic furbearers may or may not disperse into other areas depending on the operating regime of the reservoir. Considering the small amount of native habitat available in the region, there is a strong potential for overcrowding and increased competition for food and shelter to occur.

Habitat improvement techniques directed at meeting the food and cover (reproductive and escape) requirements of particular species could substantially minimize wildlife impacts. Such techniques could be designed to benefit a wide range of species. For instance, provision of habitat for waterfowl would also provide habitat for other "marsh" species. Some habitat enhancement ideas include the following:

- development of emergent and submergent cover (cattails, rushes, pondweed, duckweed) for overwater nesting birds and as brood escape cover;
- shrub and herbaceous plantings to provide cover for upland nesting birds, as well as small mammals, which in turn provide an adequate prey base for predators such as fox, coyotes, raptors, etc.;
- provision of nest structures for wood ducks and songbirds as well as nesting islands for ducks, geese, and shorebirds;
- construction of water level control structures to promote development of submergent and emergent vegetation;
- establishment of upland nest sites for raptors (raised platforms);
- selective land excavations and revegetation to create shelter belts and escape terrain; and
- exclusion of cattle grazing on rangelands adjacent to reservoir to permit development of upland cover.

6.3 Summary

Due to the extensive agricultural activity occurring at the four reservoir sites and surrounding area, none are considered to have a high capability for supporting wildlife. The Canada Land Inventory maps for ungulates and waterfowl indicate moderately severe limitations to production. No key wildlife habitat areas have been identified by the Alberta Fish and Wildlife division at any of the sites.

The greatest single impact of flooding on wildlife would be the direct loss of habitat. A significant portion of the upland wildlife habitat on the slopes would be flooded and the remaining portion that is not flooded could be susceptible to erosion due to a lack of stabilizing vegetation below. Available habitat is considered critical in a regional context at each of the reservoir sites as a result of its limited occurrence in the region.

Wherever there is a small stand of trees, shrubs, or shoreline vegetation that has not been cleared or disturbed by agricultural development, there is use of that area by wildlife for food and cover. Thus, Site 7A, which has the largest area of native land, has the greatest value from a wildlife standpoint and would be rated highest in terms of flood related impacts. Site 7B1 has a similar, but somewhat smaller, areal extent of native land and therefore would receive a slightly smaller flood impact rating. Site LB1 would be ranked as intermediate in terms of overall wildlife impacts, but would have the greatest impacts relative to its own size. Site 2, which has only a very limited amount of native land, will likely be the least impacted by the construction of a reservoir.

6.4 Data Gaps

In order to better quantify the relative wildlife value in each of the reservoir sites, the following information would be required:

- a map of the vegetative cover of the three sites;
- identification of the areas that are critical for individual species and species groups; and
- population density information for the economically important wildlife species (e.g., winter aerial surveys for ungulates and furbearers).

7.0 CONCLUSIONS

In order to determine relative environmental impacts at the reservoir sites, it was necessary to assign one overall environmental rating to each site. This rating was based on a subjective numerical ranking of each of the categories of environmental resources, including surficial geology and soils, land use, water quality, fisheries, and wildlife. This approach permitted an assessment of the comparative value or impacts of reservoir construction at each of the four sites with respect to individual issues or concerns.

The three point rating scale used to rank the specific issues is as follows:

0 - relatively no impact or concern in comparison to other sites
1 - relatively small impact or concern in comparison to other sites
2 - relatively large impact or concern in comparison to other sites.

Table 7.1 presents the summary evaluation of critical environmental issues identified in this study. The results of this summary evaluation reveal that, overall, construction of a reservoir would result in the fewest impacts at Site 2. Conversely, construction at Sites 7B1 and 7A will have the greatest impacts. It is relevant to note, however, that if it was necessary to choose between Sites 7B1 and 7A, Site 7A would be considered to have slightly greater overall environmental sensitivity due to its slightly larger size and higher value land uses. Environmental impacts at Site LB1 would be intermediate to those at the other three reservoirs but would be greatest relative to the size of the reservoir.

It should be emphasized that due to insufficient quantitative site-specific data available for this report and due to the inherent subjectivity in assigning the ratings, the totals should not be given any strict quantitative interpretation. They are used to demonstrate the relative difference in overall impacts between the sites. Full explanations of the issues identified for each subject area are provided in the respective sections of this report.

Table 7.1 Comparative Rating of Environmental Issues Identified At Four Potential Reservoir Sites in the Little Bow River Basin

Issue	Site LB1	Site 2	Site 7B1	Site 7A
Soils and Surficial Geology				
Loss of arable land	1	0	2	2
Erosion potential	0	0	0	0
Land Use				
Pasture lost	1	2	3	3
Cropland lost	1	0	3	3
Native land lost	1	0	2	3
Non-agricultural land lost	1	1	2	3
Water Quality				
Impact on physical parameters	0	0	0	0
Impact on chemical parameters	0	1	0	0
Reservoir trophic status	0	0	1	1
Fisheries				
Spawning habitat lost	1	0	1	1
Rearing habitat lost	1	0	1	1
Limitations for habitat enhancement	0	0	0	0
Wildlife				
Ungulate habitat lost	1	0	2	2
Furbearer habitat lost	1	0	2	2
Waterfowl habitat lost	1	1	2	2
Upland Game Bird habitat lost	1	0	2	3
Raptor habitat lost	1	1	2	2
Relative Ranking	**2**	**1**	**3**	**3**

Where: 0 - no impact or concern in comparison to other sites
1 - small impact or concern in comparison to other sites
2 - moderate impact or concern in comparison to other sites
3 - large impact or concern in comparison to other sites

The results of this environmental rating revealed that the different reservoir sites would suffer environmental impacts in the following order:

- **Site 2 -** least environmental impacts (most favorable reservoir site)
- **Site LB1 -** intermediate environmental impacts (less favorable than Site 2 but better than Sites 7B1 and 7A)
- **Sites 7B1 and 7A -** greatest environmental impacts (substantially less favorable than Sites 2 and LB1)

The major issues identified in reaching this conclusion include:

- **Soils** - The area of quality arable soils that will be lost from production. Site 2 had the least amount of good quality soil, Site 7B1 the most. In other respects, the sites were similar.

- **Land Use** - The amount of high valued land uses and facilities lost. The size of the Site 7B1 reservoir resulted in larger losses of high valued agricultural land than the other two sites. The presence of three active farmsteads (including a Hutterite Colony), two pumphouses, and a buried pipeline also result in major land use impacts. Site 2 is mostly pasture, and has few other developments that will be affected.

- **Water Quality** - The trophic status of the reservoirs. All four reservoirs are predicted to be oligotrophic to mesotrophic. Of the four, Sites 7B1 and 7A appear likely to have the poorest water quality due to the relatively lower flushing rates and larger potential for agricultural inputs.

- **Fisheries** - The quality of the spawning and rearing habitat lost. Site 2 has the poorest existing fishery, will suffer the least impact if a reservoir is constructed, and has good potential for downstream habitat improvements. However, Site 2 also has the lowest potential for fishing development.

- **Wildlife** - The amount of native land at each site. Wildlife is supported in the clumps of native vegetation remaining in the river valley. Site 2 has the least amount of native land remaining, and will therefore suffer the least impact if a reservoir is constructed there.

In general, the extent of environmental impacts is directly correlated with an increase in reservoir size.

This report was prepared using a small, general data base. The overall aim of the study was to identify impacts of reservoir construction on the actual sites flooded. No attempt was made to weigh these impacts against benefits to occur outside of the study area. Other studies are required, for example, to assess the economic balance between arable land lost and arable land brought into production because of available irrigation water. In addition, the feasibility of bringing water to irrigable land from the three potential reservoir sites was not considered.

The conclusions of this report are based on best estimates of the project team, and are intended to be used as a preliminary site selection tool only. Further studies will be required to confirm conclusions and to fill in data gaps identified in this report. Once site-specific data are available, conclusions about environmental impacts can be confirmed, and specific mitigation measures can be developed to diminish or eliminate negative impacts.

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Shantz, Bryan, Wildlife Biologist, Deer Ridge Consulting Ltd., Lacombe.

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8.2.2 Landowners

Akitt, Bruce and Janet	(Site LB1)
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Fath, Glenn	(Site 7A)
Jones, Brian and Lori	(Site LB1)
Leivaart, Hans and Judy	(Site 7B1)
McDougall, John	(Site 7A)
Monkman, Bob and Peggy	(Sites 7B1 and 7A)
Whiteside, Leona	(Site 7B1)
Williams, Glenn and Helen	(Sites 7B1 and 7A)

APPENDIX A

EXISTING DATA BASE - LITTLE BOW RIVER BASIN

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APPENDIX B

GUIDELINES FOR SOIL CAPABILITY FOR AGRICULTURE AND TOPOGRAPHY CLASSES

APPENDIX B GUIDELINES FOR SOIL CAPABILITY FOR AGRICULTURE AND TOPOGRAPHY CLASSES

Guidelines for Soil Capability for Agriculture

The soils have been rated for agricultural capability according to the Canada Land Inventory Guidelines (Canada Land Inventory, 1972). In this system, the mineral soils are grouped into seven classes according to their limitations for agricultural use. The first three classes are capable of sustained production of common cultivated crops; the fourth class is considered marginal; the fifth is capable of use for improved pasture; and the seventh class has no capability or potential for agricultural use.

The **classes**, the broadest category in the system, are an assessment of the degree or intensity of limitation. For example, a Class 4 soil has limitations which are more severe than a Class 3 soil. The second category, the subclass, describes the kind of limitation responsible for the class designation. Thus, when used together, the class and subclass provide information about the degree and kind of limitation. This information is useful for broad land use planning, and for determining conservation and management requirements.

The seven classes are broadly defined as follows:

Class 1 - no significant limitations to use for crops.

Class 2 - moderate limitations that restrict the range of crops or require moderate conservation practices.

Class 3 - moderately severe limitations that restrict the range of crops or require special conservation practices.

Class 4 - severe limitations that restrict the range of crops that can be grown or require special conservation practices to overcome, or both.

Class 5 - very severe limitations that restrict their capability to produce perennial forage crops and improvement practices are feasible.

Class 6 - capable only of producing perennial forage crops and improvement practices are not feasible.

Class 7 - no capability for arable cuture or permanent pasture.

It must be emphasized that soils within a capability class are similar only with respect to the degree or intensity of limitation, and not the kind of limitation. Each class includes many different kinds of soils, and many of the soils within any one class may require different management practices.

The **subclass** is a grouping of soils with the same kind of limitation. Seven different kinds of limitations are recognized as a result of adverse climate, soil, or landscape characteristics. The limiting effects of the climate denoted by a C are considered first since they affect the initial capability class or degree of limitation on a broad sub-regional basis. Next, the soil and landscape limitations are considered.

The subclasses are listed below:

Subclass N - salinity - the soils are adversely affected by soluble salts.
Subclass S - soil limitations - a combination of two or more soil limitations.
Subclass T - adverse topography - either steepness or the pattern of slopes or landscape pattern limits agricultural use.
Subclass W - excess water - poor drainage, a high water table, seepage, or runoff from surrounding areas limits agricultural use.

Topography Classes

Topo. Class	% Slope	Description	
		Multiple Slopes	Simple Slopes
2	0-2	gently undulating	very gently sloping
3	2-5	undulating	gently sloping
4	6-9	gently rolling	moderately sloping
5	10-15	moderately rolling	strongly sloping
6	16-30	strongly rolling	steeply sloping
7	30-60	hilly	very steeply sloping

APPENDIX C

COMPARISON OF WATER QUALITY IN THE LITTLE BOW BASIN TO ALBERTA SURFACE WATER QUALITY OBJECTIVES

Major Ions

Conductivity values increased downstream in the Little Bow River from a mean of approximately 350 us/cm in the Little Bow Diversion canal to a mean of 475 us/cm just above Site 7B1. Maximum values at the latter site reached 933 us/cm in March 1982. Conductivity values were considerably higher in Mosquito Creek. A mean of 611 us/cm and a maximum of 962 us/cm were recorded just above the confluence with the Little Bow River; the corresponding figures for the upstream site were 579 us/cm and 1303 us/cm. These values are typical of surface water in arid regions where groundwater infiltration provides a significant portion of the streamflow (McNeely et al, 1979). Highwood River conductivity values averaged approximately 350 us/cm ranging from 250 - 450 us/cm just upstream of the town of High River.

Concentrations of total dissolved solids followed similar trends and were higher in Mosquito Creek than in the Little Bow River. Lower concentrations in the Little Bow River reflect the higher inputs of Highwood diversion water, which has a comparatively low concentration of total dissolved solids. High salt content in Mosquito Creek probably reflects saline groundwater inputs or surficial run-off from areas of saline soil development.

The cation dominance along upper Little Bow River was Ca Mg Na K; however, average sodium levels increased dramatically in a downstream direction and eventually exceeded magnesium and calcium concentrations. Concentrations of all major ions decreased slightly throughout the open water period in the Little Bow Canal but dropped off much more sharply through the same period near Sites 7B1 and 7A. These trends reflect seasonal streamflow and aquatic vegetation growth patterns. The cation dominance was Na Ca Mg K along Mosquito Creek. As would be expected, cation trends in the Highwood River were comparable to trends in the Upper Little Bow River and there was a clear separation of the concentrations of the four major cations.

Anion dominance along the Little Bow River was HCO_3 SO_4 Cl (carbonate data are not available) and mean values for each parameter increased in a downstream direction. Late summer concentrations, however, were lower than spring

concentrations. There was a very large difference in the relative amounts of each parameter, with average bicarbonate levels being about 250 mg/L, and sulphate and chloride levels being 60 mg/L and 2 mg/L respectively. As expected, total alkalinity followed very similar trends to bicarbonates. High levels of alkalinity indicate a strong buffering capacity against acid inputs. In Mosquito Creek, sulphate was the dominant anion, followed by bicarbonate and chloride. Carbonate data were again not available. Sulphate and chloride concentrations were lower. The order of anion abundance was HCO_3 SO_4 CO_3 Cl in the Highwood River. Mean concentrations of bicarbonate, sulphate, and chloride were lower than in the Little Bow River.

Water hardness, which is essentially the sum of calcium and magnesium, is classified as being very hard (McNeely et al, 1979) throughout the Highwood River and Little Bow systems.

Organic Carbon

Total organic carbon is largely comprised of humic substances and partly decayed plant and animal material which enters stream systems through surface runoff or arises in the streams from biological activity. In the Little Bow canal mean and maximum TOC concentrations were 3.0 mg/L and 4.0 mg/L respectively. Immediately upstream of Site 7B1, however, mean and maximum concentrations of TOC increased to 6.5 mg/L and 8.6 mg/L respectively. TOC concentrations in Mosquito Creek just above the confluence with the Little Bow were even higher (mean = 22 mg/L, maximum = 39 mg/L). It should be noted, however, that these results represent only two samples collected in March, 1982. As expected, TOC concentrations in the Highwood River are similar to those in Little Bow Canal, decreasing further with distance upstream.

Suspended Solids

Turbidity, which is a measure of the ability of water to transmit light, averaged 4.4 JTU at the upper end of the Little Bow River and 11.1 JTU near Site 7B1. Turbidity levels increase drastically during spring and taper off rapidly once the spring snowmelt period has passed. Turbidity levels in Mosquito Creek followed

similar trends to those in the Little Bow River but were lower at the mouth of Mosquito Creek than the Little Bow River at the same point. This difference was largely a reflection of differences in discharge volumes between the two streams. Turbidity levels in the Highwood River above the town of High River were approximately 3.0 JTU.

Non-filterable residue (clay particles and algae) was sampled only once along the Little Bow/Mosquito Creek system which does not permit an accurate assessment of this parameter. The single sample at each site did suggest a substantial decrease in non-filterable residue concentration from the upstream end of the Little Bow River to points further on downstream. Average non-filterable residue values in the Highwood River were less than 0.5 mg/L.

Phosphorus

Average total phosphorus concentrations increased from 0.04 mg/L in the Little Bow Canal to 0.07 mg/L near Site LB1. The downstream site also had the highest maximum concentration, 0.24 mg/L. Average concentrations of ortho-phosphorus (the most readily available form for biological uptake) increased from 0.004 mg/L to 0.016 mg/L over the same distance while maximum concentrations rose from 0.007 mg/L to 0.060 mg/L. Mean concentrations of total phosphorus and ortho-phosphorus in Mosquito Creek were much higher: 0.217 mg/L and 0.136 mg/L respectively at the upstream end and 0.262 mg/L and 0.181 mg/L respectively near the confluence with the Little Bow River. Maximum concentrations of total phosphorus and ortho-phosphorus were also much higher, reading 1.18 mg/L and 0.94 mg/L respectively at the upstream site. Concentrations of these two parameters were greatest in March and least in August. Average concentrations of total phosphorus and ortho-phosphorus were 0.010 mg/L and 0.004 mg/L respectively in the Highwood River above the town of High River. The corresponding maximum concentrations were 1.25 mg/L and 0.02 mg/L.

Nitrogen

Mean and maximum ammonia nitrogen levels increased from .03 mg/L and .04 mg/L respectively in the Little Bow canal to .44 mg/L and .71 mg/L respectively immediately upstream of the Site LB1. Mean nitrate plus nitrite concentrations did not show any longitudinal trends, having low values (0.017 - 0.039 mg/L) in the upper and lower reaches and high values (0.120 to 0.198 mg/L) in between. Maximum nitrate plus nitrite concentrations were also highest (0.520 and 0.615 mg/L) at the middle stations. Mean and maximum ammonia concentrations in Mosquito Creek increased from 0.22 and 0.33 mg/L respectively below Site 2 to 0.92 and 1.00 mg/L above the confluence with the Little Bow River. Nitrate and nitrite concentrations also increased downstream along the Mosquito Creek, the mean from 0.137 mg/L to 0.264 mg/L and the maximum from 0.92 mg/L to 1.00 mg/L. Highest nitrate-nitrite levels in Mosquito Creek occurred during March and April. The erratic levels of nitrate-nitrite nitrogen along the Little Bow River probably reflect local inputs of animal wastes, which are high in nitrate.

Mean and maximum concentrations of ammonia and nitrate-nitrite were lower in the Highwood River than in the Little Bow River or Mosquito Creek. Mean concentrations of ammonia and nitrate-nitrite were below 0.02 mg/L above the Town of High River, and increased to approximately 0.06 mg/L downstream. Maximum concentrations of ammonia and nitrate-nitrite above High River were 0.09 and 0.14 mg/L respectively.

Bacteriological Indicators

Counts of both total and fecal coliforms were highly variable at all stations, with the highest values for both parameters occurring during May, June, and/or July. The highest individual counts of total and fecal coliforms occurred in the Little Bow River, although the geometric means of the individual samples indicate that, in general, counts of both tended to be higher in Mosquito Creek. Highwood River water was comparatively low in both total and fecal coliforms. The individual high counts in the Little Bow River and Mosquito Creek probably reflect localized animal waste input through run-off from grazing areas and feedlots.

Phenolic Material

Phenols, which can cause taste and odour problems after chlorination in drinking water, exhibited fluctuating mean concentrations (0.004 mg/L to 0.020 mg/L) along the upper Little Bow River. Mean concentrations of phenols did not exceed 0.007 mg/L on Mosquito Creek or on the Highwood River. Maximum concentrations of 0.032 mg/L and 0.073 were recorded on Mosquito Creek and the Highwood River respectively. Since there are no industrial discharges in the region containing phenolic materials, the aforementioned amounts of phenols would probably have come from surface run-off inputs of agricultural wastes and dead and decaying vegetation.

Metals

Mean iron concentrations increased in a downstream direction on the Little Bow River to a mean of 0.361 mg/L just above Site 7B1. Maximum concentrations were relatively constant, however, near 1 mg/L. Mean and maximum manganese concentrations did not show any downstream trends and ranged from 0.034 to 0.135 mg/L and 0.08 to 1.22 mg/L, respectively. Concentrations of iron and manganese appeared to be similar in Mosquito Creek. Mean iron and manganese concentrations in the Highwood River above the Town of High River did not exceed 0.06 mg/L and 0.012 mg/L respectively. Maximum manganese concentrations in the Highwood River were also lower in Mosquito Creek and the Little Bow River, but maximum iron concentrations were comparable.

Concentrations of most trace metals were below or near detection limits throughout the upper Little Bow River, Mosquito Creek, and Highwood River. Exceptions occurred only in the Little Bow River. Copper concentrations were noticeably elevated at both upstream sites, reaching a maximum of 0.27 mg/L, while the downstream site (LB4) showed slightly elevated maximum concentrations of lead (0.11 mg/L) and mercury (0.0018 mg/L). Those higher concentrations occurred on only one occasion each, and indicate one-time or periodic rather than continuous inputs.

Table C1 compares the water quality data in terms of the Alberta Surface Water Quality Objectives (ASWQO)(Alberta Environment, 1977) and the water quality

criteria developed for fish, water-based (non-contact) recreation, and contact recreation in the South Saskatchewan River Basin (Hamilton, 1983). The four water quality stations represent the reservoir sites (LB1, 2, and 7A, and the Highwood River respectively. The parameters for which exceedance of the objectives and/or criteria occured are discussed separately below.

Cadmium ASWQO: 0.01 mg/L; fish - 0.001 mg/L. An exceedance of the fish criteria for cadmium occurred on one occasion in summer/fall at station LB2. The concentration recorded was 0.004 mg/L. Water samples taken further upstream at station LB1 and further downstream at station LB3 on the same date showed no detectable cadmium. Further monitoring would be required to determine the significance of this exceedance. Cadmium toxicity is dependant on water hardness. Work by the American Fisheries Society (1979) indicates that at the hardness of water found at LB2 (mean=192), this concentration of cadmium (0.004 mg/L) would not harm aquatic organisms.

Coliform Bacteria contact recreation: 200 fecal, 1000 total; non-contact recreation: 1000 fecal, 4000 total. The contact recreation criterion for fecal coliforms was exceeded in 2 of 3 spring samples and 1 of 5 summer/fall samples from station M2. On the Little Bow River, 1 of 3 spring samples from station LB4 exceeded the contact recreation criterion for fecal coliforms and 2 of 3 summer/fall samples from station LB2 exceeded the contact recreation criterion for total coliforms. The fecal coliform exceedance values were typically in the range 1.5-2.5 times the criterion, while the total coliform exceedance values were 1.2 and 3.3 times the criterion. The data suggest that periodic exceedances of contact recreation criteria for both fecal and total coliforms are to be expected in both the Little Bow River and Mosquito Creek during spring and summer.

Table C1 Exceedance of Water Quality Objectives and Criteria by Proposed Reservoir Site and Season, 1982, Little Bow River Basin

PARAMETER	Water Quality Sampling Station LB1	2	7A	HR1
Cadmium	G-2			
Coliforms, Fecal		S-3	S-3 G-3	
Coliforms, Total	S-3			
Color	S-3	S-3 G-3 W-3	S-3 G-3 W-3	S-3 G-3
Copper	W-1,2			
Iron	S-1,2 W-1,2	S-1,2 W-1,2 G-1,2	S-1,2 W-1,2	G-1,2
Lead			G-1,2	
Manganese	W-1	S-1 W-1 G-1	S-1 W-1 G-1	
Mercury	G-1,2		G-1,2	G-1,2
Total Nitrogen	W-1	W-1	S-1 W-1	
pH			G-1,2,3,4	G-1,2,3,4
Phenols	S-1,2,3 G-2 W-1,2,3	S-2 G-2 W-1,2,3	S-1,2,3 G-2 W-1,2,3	S-1,2,3 G-1,2,3
Total Phosphorus	S-1,2 W-1,2	S-1,2 G-1,2 W-1,2	S-1,2 G-1,2 W-1,2	S-1,2 G-1,2

Season: S - spring (April - June)
G - summer/fall (July - November)
W - winter (December - March)

1 - Alberta Surface Water Quality Objectives (Alberta Environment, 1977)
2 - freshwater fish
3 - water contact recreation
4 - water-based recreation

Source: Alberta Environment, 1983:

Color contact recreation: 8 units. Color exceedances occurred during spring at all stations, during summer/fall at all but LB2, and in winter at M2 and LB4. Color exceedances are merely an aesthetic consideration and occur routinely during run-off events in all streams.

Copper ASWQ0: 0.02 mg/L; fish: 0.04 mg/L. A single anomalously higher copper concentration of 0.158 mg/L, exceeding both the ASWQO and fish criterion, occurred at station LB2 during winter. An even higher concentration of copper was measured further upstream at site LB1 on the same date, suggesting an upstream source of copper at that time. Additional monitoring would be required to determine if this was a one-time occurrance, or if periodic inputs of copper occur in the Little Bow River.

Iron ASWQO: 0.3 mg/L; fish: 0.3 mg/L. Exceedance of the ASWQO and fish criterion for iron were common in the Little Bow River during winter and spring and at M2 in spring and summer/fall. A simple summer/fall exceedance also occurred at site LB4. Maximum values were slighly over 1 mg/L. Only one exceedance, 0.6 mg/L during summer/fall, was recorded on the Highwood River. Naturally occurring exceedances of iron guidelines are common in streams throughout Alberta.

Lead ASWQO: 0.05 mg/L; fish: 0.05 mg/L. A single exceedance of the ASWQO and fish criterion for lead occurred at Site LB4, during summer/fall. The value recorded was 0.11 mg/L. Additional monitoring would be required to determine if this result reflected a one-time event or if periodic lead inputs occur in the Little Bow River Basin. It should be noted in this regard that a mercury exceedance occurred at station LB4 on the same date.

Manganese ASWQO: 0.0001 mg/L; fish: 0.0001 mg/L. A single summer/fall exceedance of the ASWQO and fish criterion for mercury occurred at stations LB2, LB4, and HR2. The concentration recorded at LB4 was 0.0018 mg/L but the concentrations at LB2 and HR2 were considerably lower, 0.0002 mg/L and 0.0003 mg/L respectively. The exceedances were widely separated in time; however, as indicated above, the mercury exceedance at station LB4 coincided with a lead exceedance. Further monitoring would be required to determine if periodic mercury inputs of this magnitude occur in the Little Bow River.

Total Nitrogen ASWQO: 1.0 mg/L. Exceedances of the ASWQO for total nitrogen occurred in two winter samples from station LB2, one winter sample from station LB4, and one winter and one spring sample from station M2. The exceedances on the Little Bow River were fairly small, in the range 1.1 to 1.2 mg/L, but values as high as 6.9 mg/L were recorded at M2. The pattern of winter exceedances is presumably related to animal waste inputs during low flow periods.

pH ASWQO, fish, contact recreation, non-contact recreation: 6.5 - 8.5. Slight exceedances of the objectives for pH, falling within the 8.6 - 8.7 range, were recorded during summer, once at station LB4 and twice at station HR2. These appear to be fluctuations in natural pH values, which remain near 8.5 for much of the year, particularly during the summer months, in the Little Bow River and Highwood River watersheds.

Phenols ASWQO: 0.005 mg/L; fish: 0.001 mg/L; contact recreation: 0.005 mg/L; non-contact recreation: 0.2 mg/L. The fish criterion for phenols was exceeded in almost every sample from the Little Bow River and Mosquito Creek. On the Highwood River, the criterion was exceeded in most of the spring samples and nearly half of the summer/fall samples. The ASWQO and contact recreation criterion was exceeded regularly during winter at LB2, LB4, and M2, occasionally during spring, but never during summer/fall. On the Highwood River, however, exceedances of the ASWQO and contact recreation criterion occurred only during summer/fall. The reasons for these seasonal differences in maxima are unknown. The maximum concentrations recorded were 0.015, 0.018, 0.032, and 0.073 mg/L at stations LB2, LB4, M2, and HR2, respectively. The maximum value recorded on the Highwood River appears to be attributed to anthropogenic input; however, most, if not all, of the other exceedances are probably natural fluctuations.

Total Phosphorus ASWQO: 0.15 mg/L; fish: 0.1 mg/L. The ASWQO and fish criteria for total phosphorus were exceeded in every sample taken at stations LB4 and M2 and every sample but one from station LB2. Maximum values were 0.085, 0.24, and 1.18 at stations LB2, LB4, and M2, respectively. On the Highwood River at HR2, total phosphorus exceedances occurred in approximately half the spring samples, one summer/fall sample, and no winter samples. The maximum concentration recorded was 1.25 mg/L. The frequent phosphorus exceedances in the Little Bow River and Mosquito Creek presumably reflect continuous agricultural inputs.